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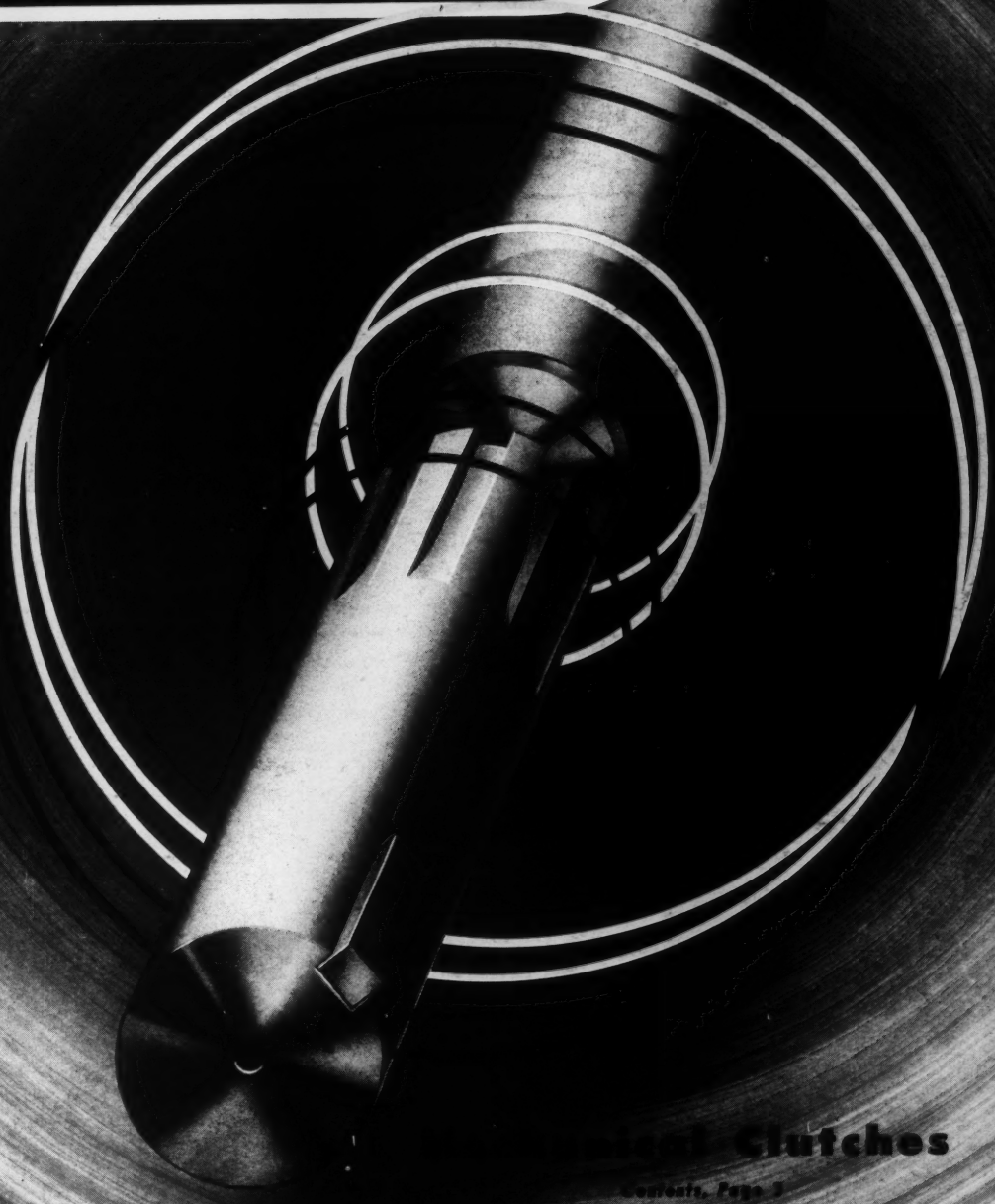
MACHINE DESIGN

August 1952



...al Clutches

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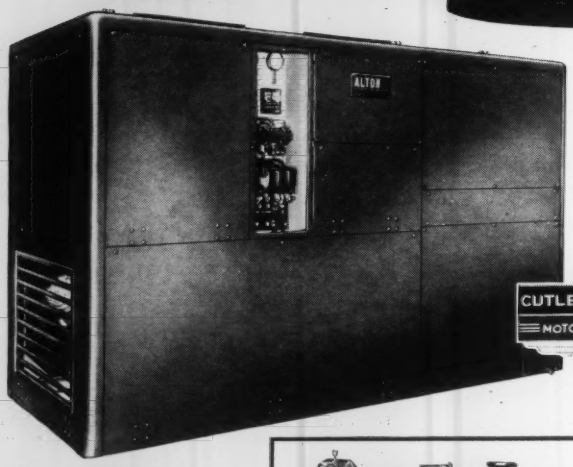
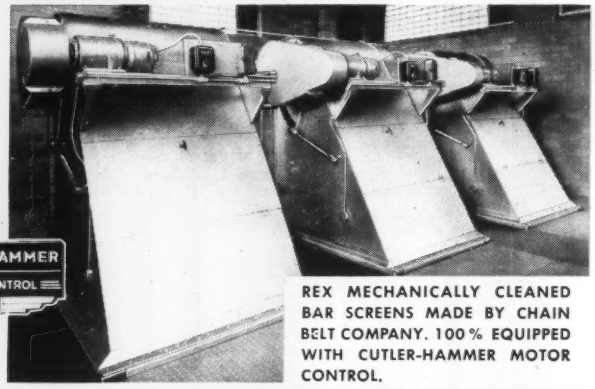
Choice of the Leaders

CUTLER-HAMMER
MOTOR CONTROL
C-H

The Mark of Better Machines



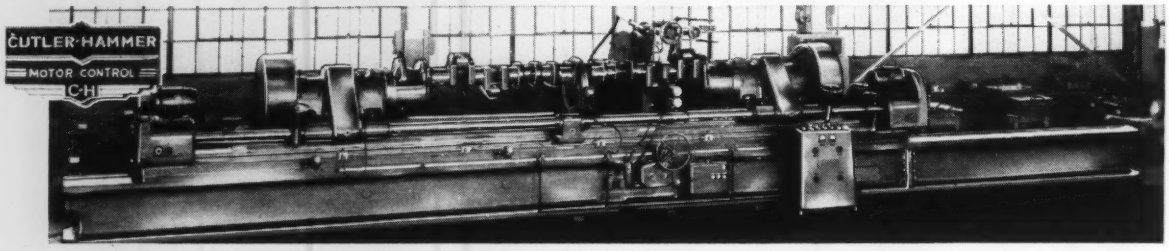
ALTON REFRIGERATED AIR CONDITIONER. COMPLETE LINE OF SIZES MADE BY ALTON MANUFACTURING COMPANY IS FULLY EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.



REX MECHANICALLY CLEANED BAR SCREENS MADE BY CHAIN BELT COMPANY. 100% EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.

PAIR OF END MATCHERS, UNITS IN A COMPLETE LINE OF WOODWORKING MACHINERY MADE BY S. A. WOODS MACHINE CO. MOTOR CONTROL 100% CUTLER-HAMMER.

LANDIS 40" x 216" HYDRAULIC GRINDING MACHINE MADE BY LANDIS TOOL CO. EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.



The road to Leadership

A market leader does better business . . . makes more money. . . has a firmer foothold than much of his competition. These commercial and practical aspects of market leadership result from the market's continuing preference for the products that he makes. His products are simply rated as superior. They better meet the users' needs and requirements. But such performance can only reflect what's *in* the products. Therefore any manufacturer seeking to govern and so predict the performance of his product in the user's hands must know and dictate the quality of the parts. *This* is the way the manufacturer can influence his market. *This* is the road to leadership.

Under the circumstances it is not surprising that leading machinery manufacturers so continuously and repeatedly select Cutler-Hammer Motor Control for their machines. Known dependability is vital where leadership is to be maintained. And Cutler-Hammer Motor Control must be a profitable choice for you. CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

MACHINE DESIGN

AUGUST 1952, Vol. 24—No. 8

THE PROFESSIONAL JOURNAL FOR CHIEF ENGINEERS AND DESIGNERS

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Over the Board

Yippee, Cowboy!

Our Western cowpoke friends (and all you Eastern greenhorns, too) will probably be interested in the new "Roundup" department starting on Page 230. No, we don't intend to go into the dude ranch business or imitate Hopalong Cassidy, but do intend to "ride herd" on all of the latest technical news, and corral the best of it for quick, easy reading. In short, "Engineering News Roundup" will cover the highlights of engineering, research and business news of interest to designers.

Happy reading, podner!

Noteworthy (?) Patents

On reviewing the *Official Gazette* of the U. S. Patent Office, our editor in charge of "Noteworthy Patents" has observed a change in makeup of the main section commencing with Volume 660. New patents are separated into three main categories: general and mechanical, chemical, and electrical. This "new look" should make it easier to follow inventive developments in these particular fields.

Despite this apparent convenience, however, mechanical patents are still interspersed liberally with those of general and nondescript nature. The first page of general and mechanical patents issued July 1 includes: a combination slip and brassiere, a nonskid stocking garter, and a shrouded bonnet with side windows which enable the wearer to peekaboo without perceptibly turning the head. Such things, of course, are quite remote from the designer's realm of interest. Or are they?

Two for The Price of One?

Commenting on the May editorial "Quantity or Quality?" Frank Short writes: "You realize and competent authorities realize the truth about quality requirements but unfortunately the man who does the hiring seems to think that an engineer is an engineer and that's that. In spite of all that has been printed about the value of the experience of older engineers, the employers still like to catch them young and bring them up in the way they should go for the rest of their lives. So, even if they consider an older man, they expect to start him about on the same financial level as an ME'52. One large firm in serious trouble on a development job recently took on two cheaper men rather than one older and more experienced man at a higher salary. P.S. They are still in trouble."

This Month's Cover

To symbolize the mechanical clutch problem—the theme of Tony Gagne's 36-page special article (Page 123)—Penton artist George Farnsworth has created the striking design which appears on this month's front cover. Lest we be accused of favoring one type of clutch over another we asked George to depict the function of a clutch rather than a particular design. We leave it to you to fill in the details after reading the article.

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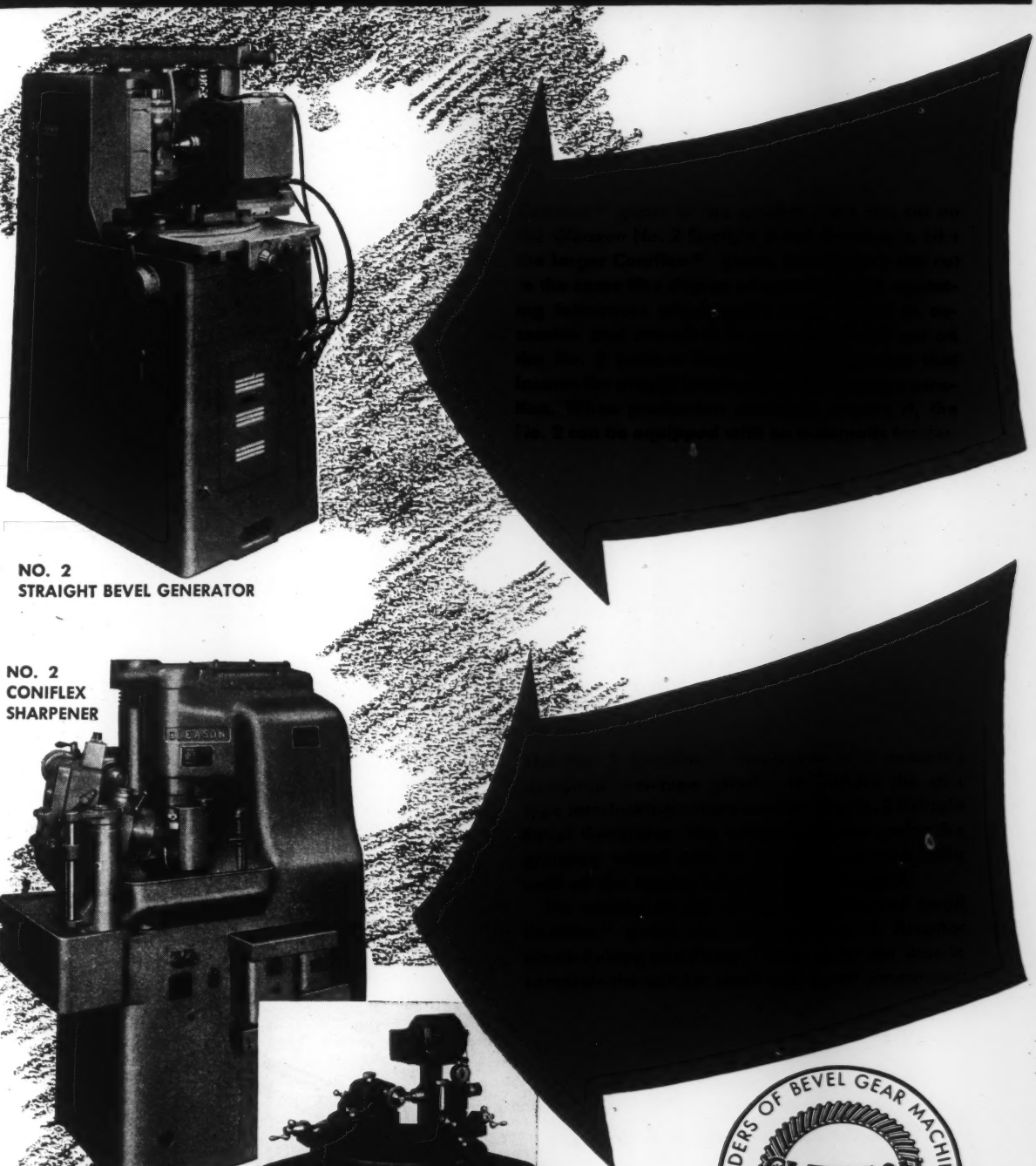
SMALL CONIFLEX® GEARS



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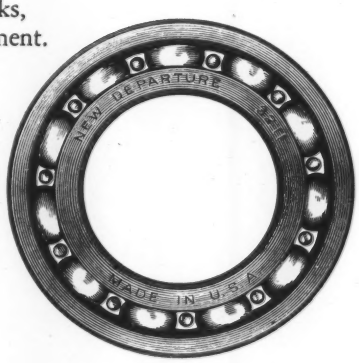
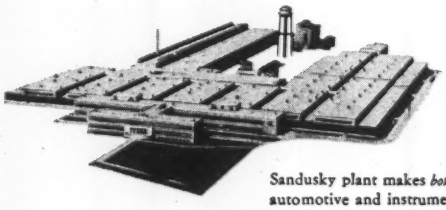


Because all New Departure ball bearings are of the same materials, receive the same heat treatment, are manufactured by the same precision methods, conversion from one to the other at New Departure is largely a matter of changing the emphasis on types and sizes.

Whatever *your* bearing requirements, feel free to call on New Departure. Its engineers, vast research facilities, and the tremendous capacity of its "guns-and-butter" plants are your assurance of the best possible production schedules.



Sandusky plant makes *both* automotive and instrument bearings.

Nothing Rolls Like a Ball...

NEW DEPARTURE

BALL BEARINGS

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NEW DEPARTURE • DIVISION OF GENERAL MOTORS CORPORATION • BRISTOL, CONNECTICUT

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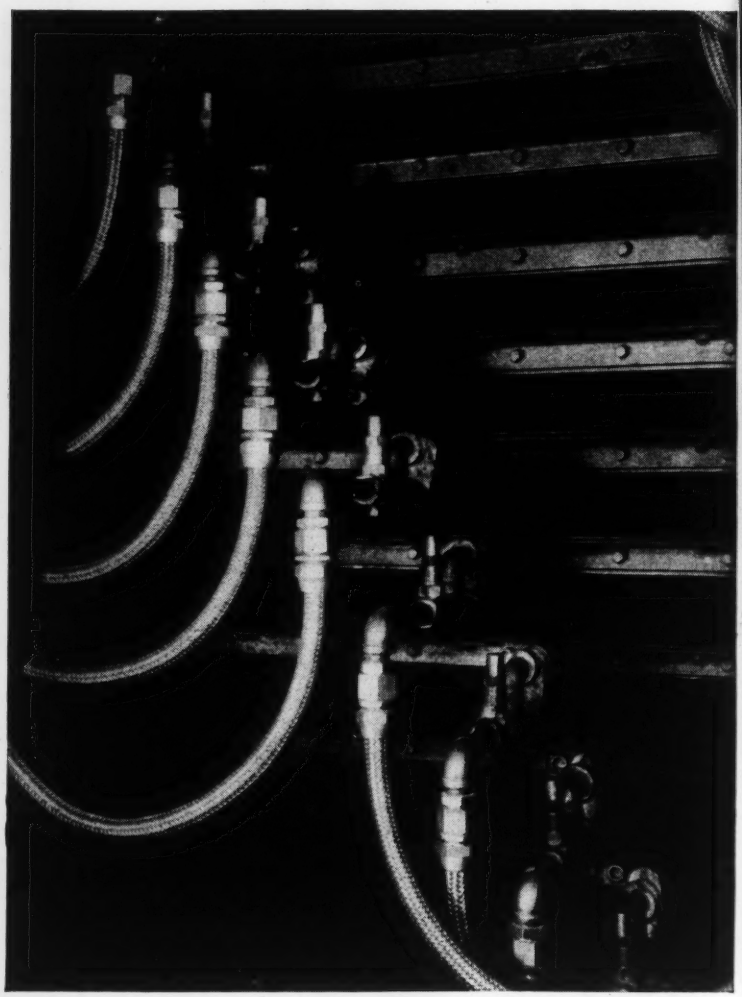
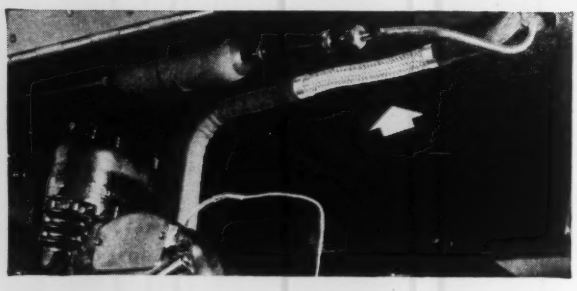
News about flexible metal connectors

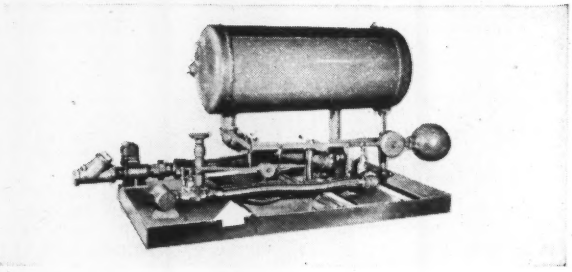
Here they prove dependable for PRESSURE, COLD and HEAT



PRESSURE Harbor Plywood's veneer press uses American ½" I.D. Seamless Bronze Connectors with braid for added pressure resistance. American Flexible Metal Connectors are ideal for this use because they're corrosion-resistant. They come with fittings attached and are easily installed. Manufacturers, like Harbor Plywood, find American Connectors the right solution to tough design problems because of their flexibility, both in assembly and operation, and their long life with little maintenance attention.



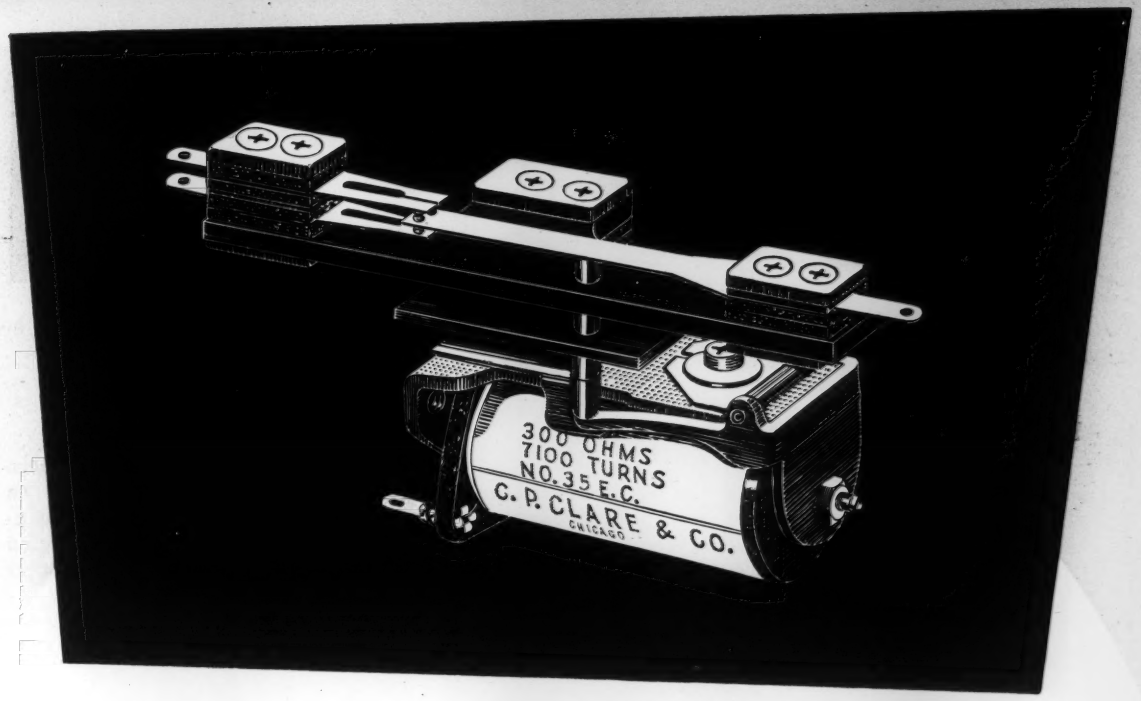
COLD For conveying Freon in truck refrigeration systems, The Schnabel Co. uses American Vibration Eliminators. These connectors operate between 10° and 40° F. at 180-200 p.s.i. American Flexible Metal Connectors are the best answer where moving lines must be connected, flexible shafts protected, or assemblies made in restricted spaces.



HEAT Morehead Manufacturing Company uses American Seamless Bronze Flexible Connectors on their "back to boiler" steam trap. This connector has the ability to resist high steam temperature and pressure as well. American Flexible Metal Connectors may also be used to carry corrosive liquids, gases, or semisolids. 52262

WRITE FOR BOOKLET SS-50—*shows how the tubing is designed, used, and installed—gives specifications on tubing and fittings. The American Brass Company, American Metal Hose Branch, Waterbury 20, Conn. In Canada: The Canadian Fairbanks-Morse Company, Limited.*

wherever connectors must move... *American* flexible metal hose and tubing



"WE WANT A RELAY THAT..."

That's the signal for ACTION at CLARE!

Almost simultaneously CLARE received requests not long ago from one of the world's largest manufacturers of radio and television equipment and from a nationwide broadcasting system. They presented similar but not identical problems.

Both involved relays for switching circuits carrying video frequencies present in the output of television cameras—frequencies ranging from almost zero to several million cycles. The capacitance between one contact spring and another, as well as between the contact springs and the frame of the relay must be extremely low. Available relays were too large and cumbersome—a typical relay extant at that time occupied 17 cubic inches—their operate, release and transfer times were too slow, and they were full of contact bounce.

These customers were familiar with the versatility of the CLARE Type J Relay. They asked us to try to adapt it for switching high-frequency currents. The Type J Video Relay was the result of intelligent cooperation between CLARE and the customers' engineers. It has negligible contact bounce and is otherwise superior to previous designs; and it occupies only about 7 cubic inches. It proved to be ideally suited to the needs of both customers, and it is now in high demand.

Bringing relay problems to CLARE by leading manufacturers has resulted in many outstanding relay developments. You, too, can save time, money and often needless experiment by contacting the nearest CLARE sales engineer. Call him today or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

First in the Industrial Field

MACHINE DESIGN TOPICS

. . . IN ENGINEERING AND RESEARCH

Water-Soluble Silicone Sheds Water

Soluble in water, a new silicone can be applied directly to surfaces or used in water mixes to impart water repellency. Described as sodium methyl siliconate and available only in experimental quantities, the chemical developed by General Electric is expected to find immediate use as a masonry and concrete water repellent, although other applications in finishes, textiles and chemical processing are foreseen.

Converter "Decorrodes" Exhaust Gases

An exhaust-gas converter, designed to remove chemical contaminants from exhaust gases, will be developed and tested for the Air Force by Ryan Aeronautical Co. The new device, called a "decorroder," will render the gases useful for cabin heating, anti-icing and other heating applications in aircraft.

Radio Mast Design Saves Money on Snorkel Subs

Originally forged and pierced from solid stainless-steel billets, radio and radar masts for snorkel subs are now being built of low-alloy steel tubes covered with a Monel cladding. About 11,320 tons of steel were required to produce 400 masts of the original design with a total finished weight of 400 tons. With tubing, only 465 tons of metal are required, of which about 50 tons are machined away. Savings will amount to about $2.5 million.

Spare Parts Bolted to Machines

One large manufacturer is stipulating that machine tools with special components instead of standard must have replacements for these components affixed to the machine. For instance, a machine designed to use a flange-mounted or shell-type motor would have an extra bolted to the machine as a spare. No matter where the machine is moved in the production line or between plants, the spare is always immediately available. And space-consuming inventories of special components are greatly reduced.

Chain Radar Tracks Guided Missiles

The flight of guided missiles is automatically tracked, recorded and photographed by a chain radar system at White Sands Proving Ground, N. M. Tracking is initiated simultaneously with launching, and data from the master station are automatically transmitted to the first relay station by a complex wire and radio network, positioning the radar set at that station to track the missile when it comes in range. At the terminal end of the missile's flight, radar automatically trains cameras with telescopic lenses on the missile as it dives into the target.

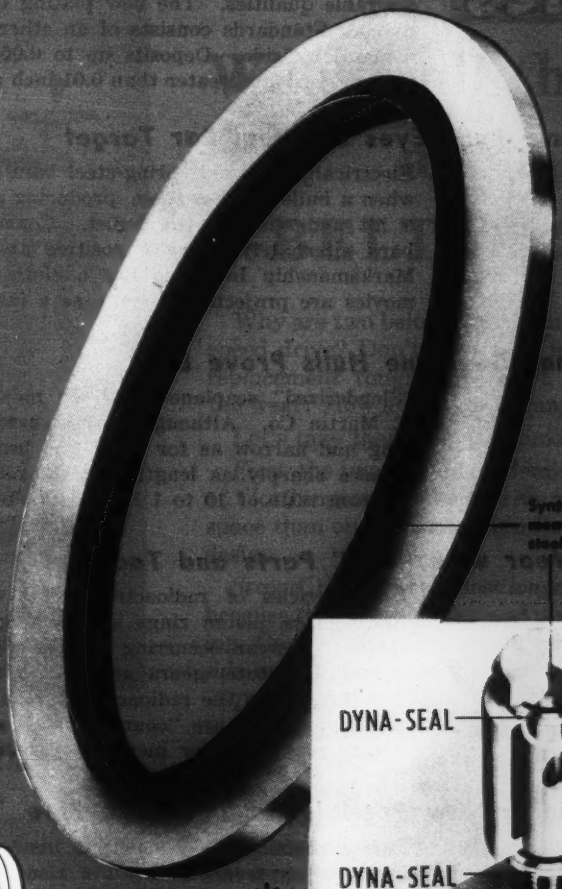
Successful Process for Electrodepositing Aluminum

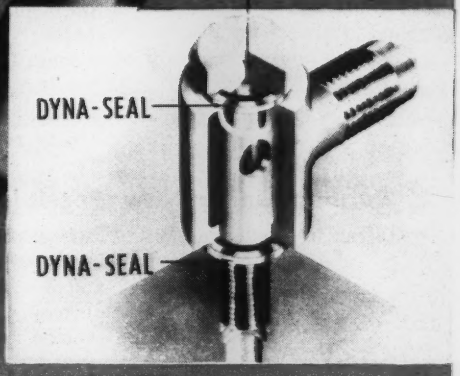
Dense, ductile deposits of aluminum are being obtained in a new type of organic plating bath at room temperatures. Aluminum cannot be plated from aqueous solutions, and although nonaqueous solutions have

PRP announces a New Product

...the Dyna-Seal*

thoroughly proved — a simple face-to-face seal!





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U.S. Patent 2,455,982

Synthetic rubber sealing member bonded to steel ring for sealing circular flat surfaces, bolt heads, rivet heads, flanges, special fittings — no grooves necessary. Seals all pressures against water, all types of petroleum products, many other fluids and gases. Countless applications. Write for free handbook.

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TOPICS

been tried in the past, deposits were lacking in purity, ductility and other desirable qualities. The new plating bath developed by the National Bureau of Standards consists of an ether solution of aluminum chloride and a metal hydride. Deposits up to 0.05-inch thick have been prepared although deposits greater than 0.01-inch are likely to be visibly crystalline.

Sparks Show Bull's-Eyes on Steel Bar Target

Electrically charged spring-steel bars in a new target are short-circuited when a bullet strikes them, producing a spark which simultaneously shows a hit and shatters the bullet. Consisting of about 150 tapered-section bars alternately charged positive and negative, the grid developed by Marksmanship Inc. also has a cloth or plastic screen on which action movies are projected to serve as a target.

Long, Skinny Seaplane Hulls Prove Best

"Slenderized" seaplane hulls are most efficient, according to the Glenn L. Martin Co. Although hydrodynamic efficiency is about the same for long and narrow as for short and broad hulls, aerodynamic efficiency increases sharply as length-to-beam ratio increases. An optimum length-to-beam ratio of 15 to 1 has been determined.

Testing Wear with "Hot" Parts and Tools

Tiny particles of radioactive metal worn away during wear testing of "hot" gears, piston rings and cutting tools provide an indication of the amount of wear occurring during use. According to the American Petroleum Institute, gears and piston rings are first made radioactive at Oak Ridge. As the radioactive particles are carried away by the lubricant oil stream, they are "counted" with a Geiger counter. ASME reports a similar procedure for measuring wear of cutting tools.

Rubber Lining Now Possible on Small-Size Pipe

Pipe as small as 1½ inches in inside diameter can be lined with rubber in a new process. Lining can also be applied on special designs, shapes and 4-inch pipe with three 90-degree bends. The rubber lining method developed by La Favorite Rubber Mfg. Co. prevents electrolytic corrosion, erosion and abrasion.

"Back Pack" TV Camera Operates on Batteries

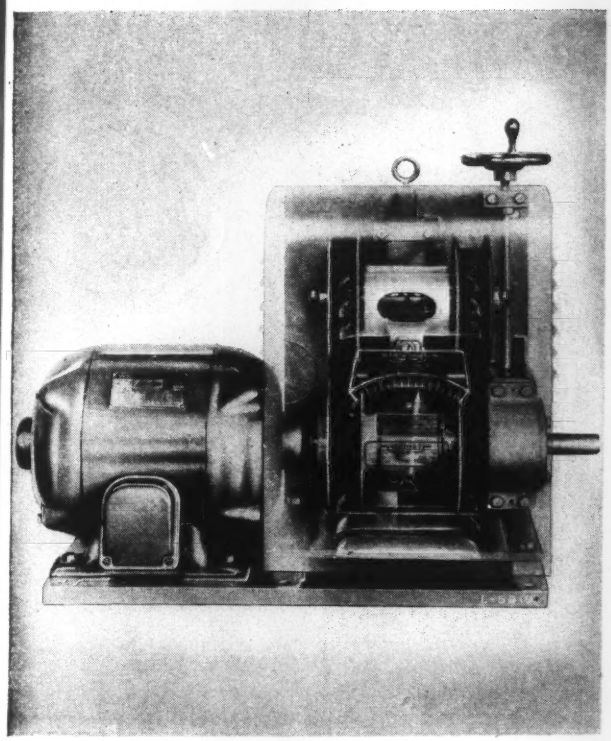
Able to transmit over a quarter of a mile, a UHF television camera and transmitter which can be carried by one man is powered by batteries only. The camera weighs only 8 pounds, while the transmitter and control-signal receiver, complete with batteries and dynamotor, weighs only 45 pounds. A Yardney Silvercel battery pack with a total weight of 8½ pounds powers the equipment.

Simplicity Necessary in Laboratory Instruments

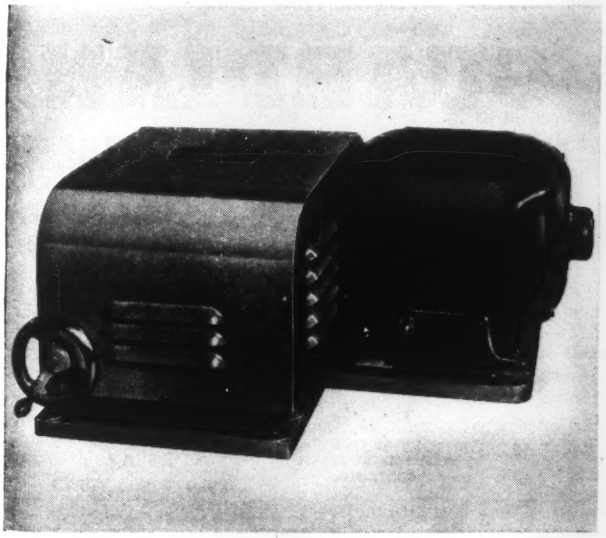
Simplicity of operation should be one major objective in laboratory instrument design, with the fewest operational steps and logically organized controls. Also suggested by R. C. Mallett of Standard Oil are increased accessibility for maintenance and repair—possibly by building instruments with removable units to minimize down time—and increased versatility without added complexity.

Plastic Pipe Patch Mends Sunflower Bursts

Applied in 7 minutes and ready to stand working pressures 20 minutes later, a plastic patch developed by the Navy can mend jagged ruptures or sunflower bursts, or can join the ends of completely severed pipe. Patching material consists of fibrous glass cloth, resin and an activator, and fibrous glass tape. No surface preparation other than wiping the surfaces dry is required, and no outside heat is needed to apply the patch.



PHANTOM VIEW SHOWS NARROWER BELTS OF WORTHINGTON ALLSPEED DRIVE that give smoothest operation, highest range of variation in smallest space, longest belt life.



ALLSPEED MOTOR DRIVE is available in both horizontal (shown here) or upright models. Standard NEMA frame motors are used on all sizes.

What's all this talk about 2-BELT DESIGN?

Why are two belts better than one in a variable speed drive? Don't they take more space? Isn't replacement tougher? Doesn't this mean twice the wear? How about speed ranges?

Let's take them one at a time.

First, the two-belt or tandem-belt construction of Worthington Allspeed Drive actually takes *less* space than one belt and permits a more compact design.

Second, the two belts last *longer* by far than one because they're narrower and wear less from flexing. Constant belt tensioning prevents excessive side wear and side compression, too.

Third, belt replacement, when necessary, is *easy* —no dismantling of the complete unit nor disconnecting of driver and driven shaft is required.

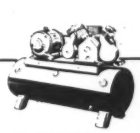
Fourth, you get whatever range of variation your equipment calls for. Tandem-belt design actually makes possible a *greater range* of variations and a more compact machine.

Send for Bulletin AS-1600-B6. Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Allspeed Drive Division, Holyoke, Massachusetts.

Precision lathes get stepless speed variation at no extra cost

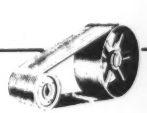
By replacing the back gears with an Allspeed Drive, this precision lathe operated more smoothly and quietly over a greater range of spindle speeds. And at no extra cost—since the back gears were eliminated. The new lathe has *stepless* speed control and is easier to operate. The machinist merely pushes a "Fast" or "Slow" button to change spindle speeds. Space? The Allspeed unit takes less than the conventional gears and has fewer operating parts.

AS.2.1



COMPRESSORS: AIR-COOLED, WATER-COOLED

PUMPS: CENTRIFUGAL, ROTARY, STEAM, POWER



MULTI-V-DRIVES: QD SHEAVES AND V-BELTS

ALLSPEED DRIVES: WORTHINGTON ALLSPEED

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Allspeed Drives

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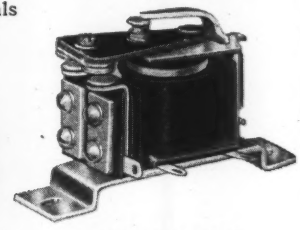

SERIES 220 A.C. RELAY

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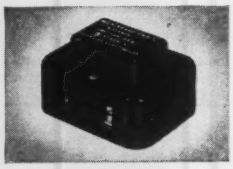

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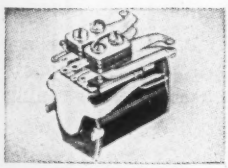

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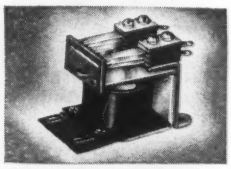

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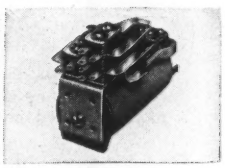

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Meeting Competition

THE shortage of engineers has been considerably intensified because graduates of earlier years cannot cope with the problems now before us." So observes Dean Hollister of Cornell in his recent presidential address before the American Society for Engineering Education. Pointing out that even though much of their training may understandably have become obsolete he implies that if that training had been sufficiently thorough in basic principles it would have permitted these graduates to keep abreast of new developments through reading.

If the insignificant demand for current advanced engineering literature such as, for example, the papers and transactions of the ASME is any criterion, an overwhelming majority of today's working engineers must feel that such literature is beyond their understanding. In fact, many engineers not only admit but seem proud of the fact that they cannot understand or use "this long-hair stuff."

"In this country," continues Dean Hollister, "we have relied heavily upon the laboratory report and problem methods of teaching. In Germany, for a number of decades, it has been the policy to use the project method . . . focusing largely upon design. The project method encourages resourcefulness, ingenuity and individual judgment, whereas the problem method encourages belief in one and only one solution."

Therein lies a key to the difficulties experienced by so many U. S.-trained engineers in understanding and applying advanced scientific and mathematical principles. Having been taught to grind out answers by substituting in handbook formulas, they are at a disadvantage when it becomes necessary to analyze a problem from first principles. Inasmuch as the Soviets are known to have captured and undoubtedly are exploiting many German-trained engineers, we cannot afford to entrust future engineering developments here to a type of approach which mitigates against resourcefulness, ingenuity and individual judgment.

Thanks to Dean Hollister's clear call to action, the engineering colleges are at last giving serious attention to what amounts to meeting competition. It is earnestly hoped that they are not too late and that the near future will produce a crop of graduates trained to do real creative thinking.

Colin Carmichael

EDITOR

DEVELOPING AN

By D. T. Gunderson
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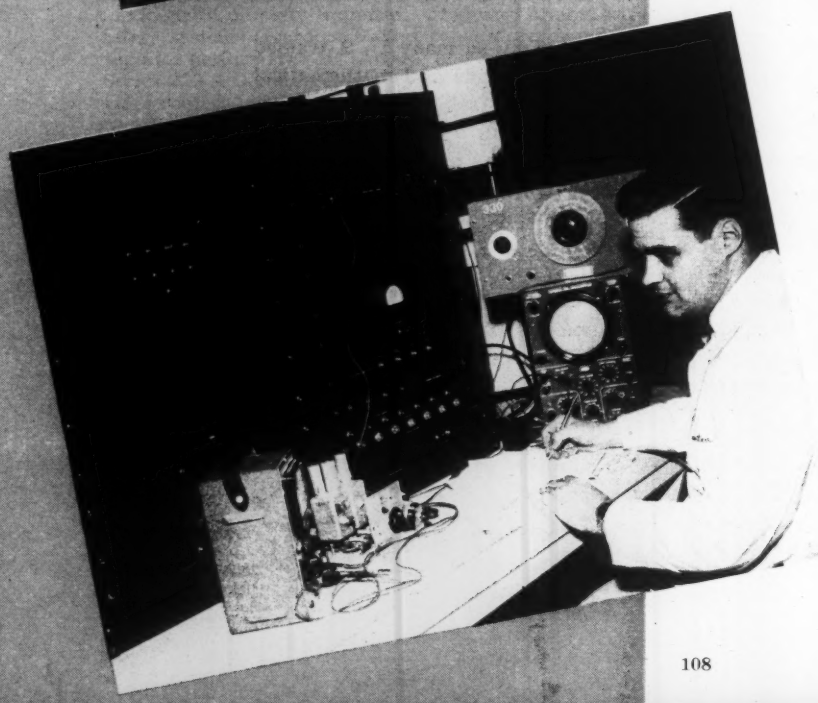
Cook Electric Co., Chicago, Ill.



THEORETICALLY, engineers are the products of schools and colleges, but practically they are largely the result of development and of training in industry. One educator frankly admitted "We have educated them; it is up to industry to train them."

Engineering is a complex mixture of science and men, and as science becomes more complex, men become more important. Their sound development and training should be a relatively steady and ordered growth. Too rapid and too forced growth leads to brittleness—much as in plants that are forcibly developed. Time is required for strengthening and maturing of each increment of growth so that each may properly support successive increments of growth.

Training of men can be a very complicated process. But it need not be if our sights are true and

Top—Interviewing a new engineering applicant aids in determining his interests, point of view, mental habits, inherent honesty, and technical competence

Left — Through actual assignments in the laboratory and proper guidance the young engineer "stumbles" upon the solution, developing his confidence and the habit of responsibility

TRAINING ENGINEERS

A practical approach to this all-important subject involves turning selfish interest into constructive and co-operative channels

our objectives clear and honest. Mental honesty is its keystone. Nothing inhibits sound engineering training like mental dishonesty. Training is frequently attempted in the form of "Ten Easy Lessons" which tends to degrade, even debase the profession and to lower it to the status of the trade. Training, in the final analysis is an endless process, for there are always new situations which arise and for which no formula has been developed or prescribed. In fact each situation requires, usually, a different formula; hence, the basic problem in training and development is to discover the common denominators which are applicable to many or most situations and, therefore, are suitable for initial consideration or as foundation for a formula to meet particular situations.

Each of us sees the problem of training a little differently, because our experiences are anything but precisely the same. Yet, the solution to a specific problem should be somewhat unique (even in the form of first approximations) so that no matter what our particular experiences may have been, the solutions should show considerable agreement among them. If not, someone (or everyone) is unduly biased and is probably headed more or less in the wrong direction.

For what it may be worth, the following is an outline and discussion of some of the basic elements or phases in the development and training of engineers as seen from one engineer's vantage point and experiences. The major categories are

1. Interviewing the applicant
2. Solving practical engineering problems
3. Developing habits of responsibility
4. Learning by training others
5. Maturing through delegation of authority
6. Using basic thinking tools.

It should be observed that, whereas specific means are suggested, the purpose of this article is not to emphasize specific ideas, but rather to develop the philosophy underlying the ideas. Once the spirit of the method is caught, the suggested means will become obvious and other means can readily be devised to cope with any situation. The best means is never the same for any two situations.

The Interview: The training of an engineering candidate from an industrial point of view does or should begin with the interview. As in many other things, a good start is important. The interview should reveal the caliber of the candidate and should lay or uncover the foundation upon which subsequent development can be built. The candidate's interest (or lack of it), point of view, mental habits, as well as his technical competence should come under close scrutiny, as practical engineering is a complex mixture of all these factors and more. Any deficiencies must be reduced by subsequent development and training.

The young engineer should have a genuine interest in his chosen field. It is easy to advise him to "develop genuine interest," but it is anything but easy to tell him how. When interviewing engineering candidates some interesting angles develop when the question of interest is raised. Too often the candidate admits that he is in engineering for reasons other than interest. In fact genuine interest may seem to be conspicuous by its absence.

Interest is the real driving force and the sustaining power in engineering, in fact, in any profession. If an engineer is not genuinely interested—or cannot become interested—he had better change to something else. We should not be too severe with the engineering candidate that fails on interest. Nevertheless, orienting our training of engineering candidates toward the development of interest is important both for the man and for the profession.

If we analyze a given situation we may find that interest is only dormant (fortunately). Sometimes it can be awakened by encouraging a candidate to sharpen the basic tools of the profession so that engineering becomes a challenge, even a hobby, rather than a chore or a bore. Nothing is more deadening than working on something without interest, and

real growth is next to impossible.

The key to interest is understanding with freedom of thought, supported by natural aptitudes. In the interview all that can be done is to sense any native interest and possibly to detect a feasible approach for strengthening such interest. The method of training is designed both to awaken and to maintain interest.

Adopt a long point of view! It takes quite a while for most of us to learn enough to make a contribution to society. Some, of course, never do; others succeed almost overnight. Because most of us follow the "long pattern" it is very desirable that at the outset of our careers we adopt a long-range point of view. Today, as though in contradiction, most men want to succeed in a hurry; and some do.

Too many men never really succeed, mostly because they drift about aimlessly from mirage to mirage. Some of my favorite questions when interviewing an engineering candidate are "What do you want to do, say, ten to twenty years from now? What are you doing toward achieving that goal?" Now and then some intelligent answers are received, but not too often. Many do not even seem to comprehend the question; they hardly comprehend the present, not to mention an "eternal" twenty years or more in the future.

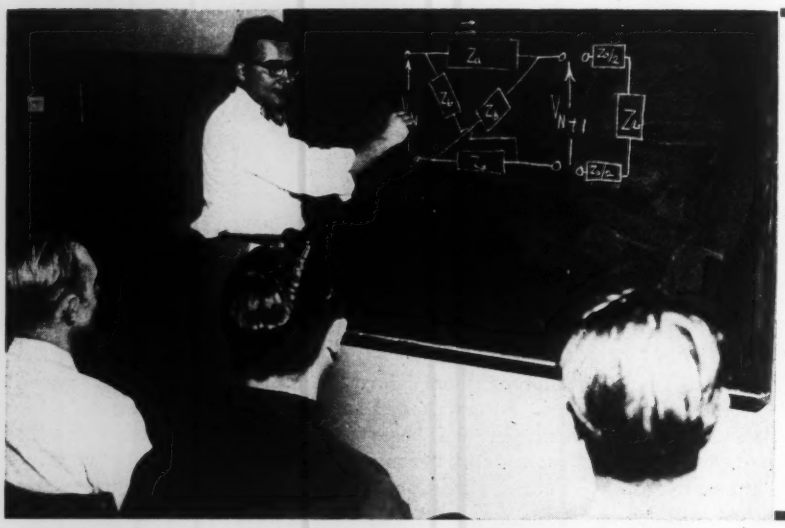
It seems almost axiomatic that if a man does not fix his sights on some objective and work constantly to keep that objective clear, he will surely fall into one of those "hit and miss" careers which are altogether too common among professionally trained men. A long point of view has a steadying effect on anyone; momentary failures seem less fatal, and momentary successes less important than the larger ultimate long view objectives. The same sense of proportion resulting from an adequate viewpoint tends to become part of and to be reflected in one's every thought and action. The long view objective becomes both the stabilizer and rallying point for one's best efforts.

Obviously, you cannot "dial" a candidate to long range thinking but you can guide him toward that objective. The successes achieved during training can be stimulating advances toward the larger objectives. It is important to succeed, if only occasionally, and the proposed training program allows *all* to succeed because success is *never* at the expense of the other fellow.

From time to time it is expedient to jog the candidate's mind with infrequent, but calculated discussions, and thereby helping him to find or to go after, or keep after suitable objectives. Once a candidate has the objective clearly in mind, and is stimulated by spaced successes, self-effort is reasonably automatic. The problem and the job of development and training is to initiate the development of these forces (interest plus objective) and to develop it to a point where it can hold its own.

When an applicant applies for a job he naturally puts his best foot forward. It is the job of the interviewer to get beneath this veneer and to obtain a true evaluation. For this reason the purpose of a question at such times is not always what the question implies. One question which may be asked is, "What do you really know about the field in which you are seeking employment?" The real purpose of the question is to obtain a measure of the candidate's mental honesty. Even if the interviewer knows very little about the particular field (and this sometimes is a help) it is relatively easy to detect a job of selling from one of simple honesty.

Since mental honesty is the keystone to any engineering success, need for guidance along this line requires detection early. Should the candidate stray, it is relatively easy to stop the inquiry before the candidate gets himself into an embarrassing situation, and then to lead the conversation toward safer ground. The diverting thought in most instances is usually "You cannot know everything, nobody does." To which the candidate frequently breathes a sigh of relief, punctuating your inference. Again, the method of training is designed to encourage mental honesty and once the steadying effect of simple



Young engineer leads a seminar discussion. This important phase in training develops confidence and the ability to express himself forcefully and concisely

Daniel T. Gunderson, administrative engineer and physicist, has put in practice the philosophy proposed in this article with unusual success. At present he is administrator for the systems engineering and servomechanisms sections for Cook Research Laboratories. Previously, he was chief engineer for Askania Regulator Co. and engaged in research, design and development of automatic control devices. Before joining Askania, the author was in charge of the magnetic testing laboratory for Armco Steel Co. and had been engaged by the Grigsby-Grunow Co. for radio tube development and design work.

honesty is experienced, continuation along this line is natural.

Practical Engineering Solutions: Most of us will recall the stereotyped problems of our school days. We were really smart those days. We could complete problem assignments in a single night and get the right answers, too. What a shock to be confronted with just one practical problem and to find oneself floundering, even stymied, for days. Perhaps if we had learned how to study before we left school, the transition would not have been so drastic. How can the shock be eased and the engineering candidate be launched less roughly on his career?

Most of us can probably recall our engineering successes and how we "stumbled" onto the solutions. These initial successes gave us courage to tackle increasingly difficult problems. This idea of stumbling onto a solution is important because the act of stumbling is a thrilling experience in learning. After few such thrilling learning experiences, we were well on our way to becoming engineers.

The problem, therefore is, how to help the engineering candidate to stumble onto his first practical engineering solution. This is not easy. The tendency is to "tell" him the answer in order "to save time" and, thus, the opportunity for training is lost. If time permits (and if you want to train your men you must take time) you ask leading questions or use similar techniques until your candidate "stumbles" onto the solution you want him to find. With a few such experiences, your candidate is also on his way to becoming an engineer (if he is engineering caliber).

Most important, your engineering candidate is now capable of moving and producing on his own. Equally important is the effect on the guiding engineer who invariably turns out a stronger and better engineer, who has now demonstrated and strengthened his ability to handle men and to get work out of them.

Habit of Responsibility: Fortunately, engineering is something more than facts and figures. It is also men. Responsibility has always been recognized as a builder of men. Few men, when given the opportunity, shirk from accepting responsibility. Responsibility is sometimes delegated without authority. But this is not responsibility in any true sense because there can be no responsibility without authority to support the responsibility.

The problem as it relates to developing and training is, how can we best develop responsibility in our engineering candidate? Development of responsibility starts with development of self-confidence, without which the sense of responsibility cannot be initiated.

The first time an engineer assumes responsibility, he is subjecting himself to a shock exactly like jumping into deep water for the first time. The specter of "sink or swim" can be terrifying. If, however, he happens to have a friendly swim instructor handy for the first plunge or two, or until he has developed a feeling of confidence, the shock is considerably lessened and a real liking for responsibility may develop.

Since business plays "for keeps," responsibility is sometimes delegated reluctantly. One of the basic problems in developing engineers through responsibility is to seek a method by which responsibility and authority can be delegated with reasonable safety and by which, at the same time, sufficient freedom can be given to the engineering candidate to insure sound development.

Delegation of responsibility must be accompanied by an indication of confidence as well as by an air of sobering caution. One simple form of delegation of authority that has been used effectively in starting men along the paths of responsibility has been to explain carefully what is required and then to conclude with the challenging thought that the only real error that the engineering candidate can commit in carrying out his assignment is not to call for help soon enough, if required. Now the meaning of this may not be immediately obvious to the candidate. It may require some amplification or clarification. Specifically, he is advised that he will be judged primarily by the quality of his decisions and not by the sources of his information. He will be further advised that, even if the information comes from a superior, the decision and responsibility for the decision is still his.

The effect of these thoughts varies from candidate to candidate. His reaction to these freedoms and safeguards will indicate his strength or weakness. From it the average engineering candidate seems to sense

the two essential helps—one, of confidence; the other, of friendly assistance if required. There are also certain by-products of the method which are not too obvious. Since the engineering candidate now feels his responsibility, he also feels the need for talking things over, even with his superior, and thereby "the boss" is automatically kept "fully informed," as most bosses usually demand but don't always get. Moreover, there is no need for covering up or for deception. Quite the contrary, interest in the assignment is usually higher than normal with attending benefits which only the force of interest can impart.

Training Others: Having developed some feel for practical engineering solutions and also having developed some sense of responsibility, the candidate may be ready for the next step in his training. It is to grow by training others—to do for others what has been done by others for him. The problem is not how to develop others but how to *learn* to develop others. Once an engineering candidate has tasted the thrill of finding engineering solutions, it is not easy for him to forego this thrill and to allow someone else to have it in his place. But this is precisely what must transpire if the candidate is to grow in stature and to assume increased responsibility through management of others. The practical problem before our engineering candidate becomes: how to get the work done by others. This calls for techniques relatively new to him, for as yet he has no real experience in delegating authority.

The technique he must develop is the same as that by which he was guided into his first practical engineering experience—by guiding his assistant with suggestions and leading questions to stumble onto the desired solution, but definitely not by dictating the solution in the interest of time, or to garner credit for himself. Both of these are great temptations in the interest of making a showing for himself in his newly expanded responsibility. It takes quite a man to let the other fellow have credit for the solution but, if his immediate superiors are cognizant of the method of training and of getting things done, his ability to lead others will be abundantly clear.

Of equal importance is the sense of confidence which the method gives to the candidate. He is fairly sure that his assistant knows what is to be done because the assistant himself has defined it. The candidate is also fairly sure of good results because everyone is interested in his own ideas. If, on the contrary, our candidate had defined the solution, he could not be too sure that the assistant fully understood and would probably have to keep much closer tabs on the progress of the work. Again, since the assistant has a personal interest in the idea, human nature being what it is, he will tend to keep his superior (our candidate) fully informed and generally contribute to the development and perpetuation of a sound, co-operative working atmosphere. As a by-product, and of no small value, the assistant will develop confidence in our candidate as a leader and will cheer rather than envy his further rise in the organization. The idea of "give and ye shall receive" probably bespeaks a subtle truth difficult for us mortals to understand.

Delegation of Authority: If our engineering candidate is of sound engineering caliber, with capacity for expanded responsibility, he will eventually be pushed into management. He cannot help himself because, as the saying goes, "there is always need and room at the top." Here his problems are not so different. In fact, he has specifically two duties to perform: one, to choose men to do the job; the other to delegate authority to get the job done. If he himself has been the product of the discussed training and development program, he will find little difficulty in adjusting himself to the slightly new conditions.

From experience, he knows what the jobs require and can proceed to make his choice of men accordingly, even as he learned in previous assignments. Opportunity for close guidance is considerably

New engineering program is outlined to group leaders by section chief. Close cooperation is developed by this method and the executive is kept in close touch with developments through reviewing the progress of a new project

lessened, more so the further up in management echelon he moves. Yet the same guiding principle seems to apply—to clearly define the objectives and delegate the authority to achieve the objectives. As on the lower levels, men working under such conditions will feel the desire to keep the boss informed, and to talk about their jobs. If in doubt, they will ask top management for advice, even for decisions because their responsibility is to get the right answer regardless of source. They are judged by the quality of their decisions and not by how they arrived at such decisions.

Basic Thinking Tools: As might be expected, the basic tools of any profession are much the same. They are elementary and, in trained hands, are very powerful. They consist of a vigorous vocabulary and a developed ability to use it. One of the most difficult problems in training and developing men for professional work is to transmit an appreciation for these simple tools, difficult because appreciation can only be acquired by experience. Since few can sense the importance, most men must be "trapped" into the experiences which will give them a taste of the pleasant possibilities.

While much can be done by formal education, more is accomplished if the trainee can first be trapped into discovering the pleasant fact for himself. The simple story which I usually tell to encourage a trainee is to recall how I once reviewed an old subject. Finding the ideas a little hazy, I resorted (for no good reason at all) to looking up each word for which the meanings were not fully understood. The meanings of the words and paragraphs became surprisingly clear and as a further surprise I found that the now clearly understood words stood out on subsequent pages as though in relief as I continued into the book. Needless to say, what I read was better understood and was also more interesting because of clearer understanding. More important, perhaps, is the realization that a word, the meaning of which is hazy seems to carry the haze along with it and becloud every idea with which it becomes associated. A hazy idea is uninteresting!

Developing and sharpening the basic tools, vocabulary and effective use of it, are effective means for awakening and releasing dormant or arrested interest in any engineering candidate. It may well be the real beginning of engineering sense in the candidate. It should be obvious that once the use of the basic tools is mastered, acquisition and mastery of engineering facts and figures becomes relatively easy, and a pleasure to pursue.

Some colleges offer courses in how to read, write, speak, even how to study—a clear indication and recognition of the deficiencies common to too many college students and graduates. These, however, should have been learned in preparatory school. What a pleasure engineering and other professional courses might have been if there had been proper preparation in the basic tools.

As engineers we would expect the teaching methods and techniques to be designed and directed toward the desired objectives—a good vocabulary and its effective use. The subject of preparatory training cannot be disposed of in a paragraph or two. For the present purpose, however, mention of two proposed modifications in the present teaching techniques will suffice. These consist of: One, a shift in emphasis from sterile spelling and pronounciation to emphasis on development of a vigorous vocabulary. Two, the use of all preparatory subjects as practice materials in developing the ability to read, write, speak, and study. Little or no emphasis should be placed on memorizing facts and figures which seldom remain static.

Perhaps too many men in high places of education do not appreciate the unpleasantness of half-drowning while taking a course because of the student's inadequate training in basic tools; nor do they realize the number of good men who actually do drown while trying to gain the educational goals because of improper preparatory educational techniques. One educator remarked, "It is a wonder we do not kill them."

These methods of development in training are a philosophy rather than an outline of training procedure. This is as it should be. Man is not a machine, although individuals are working hard to develop and prove the contrary. Through competition we are encouraged to race for the top.

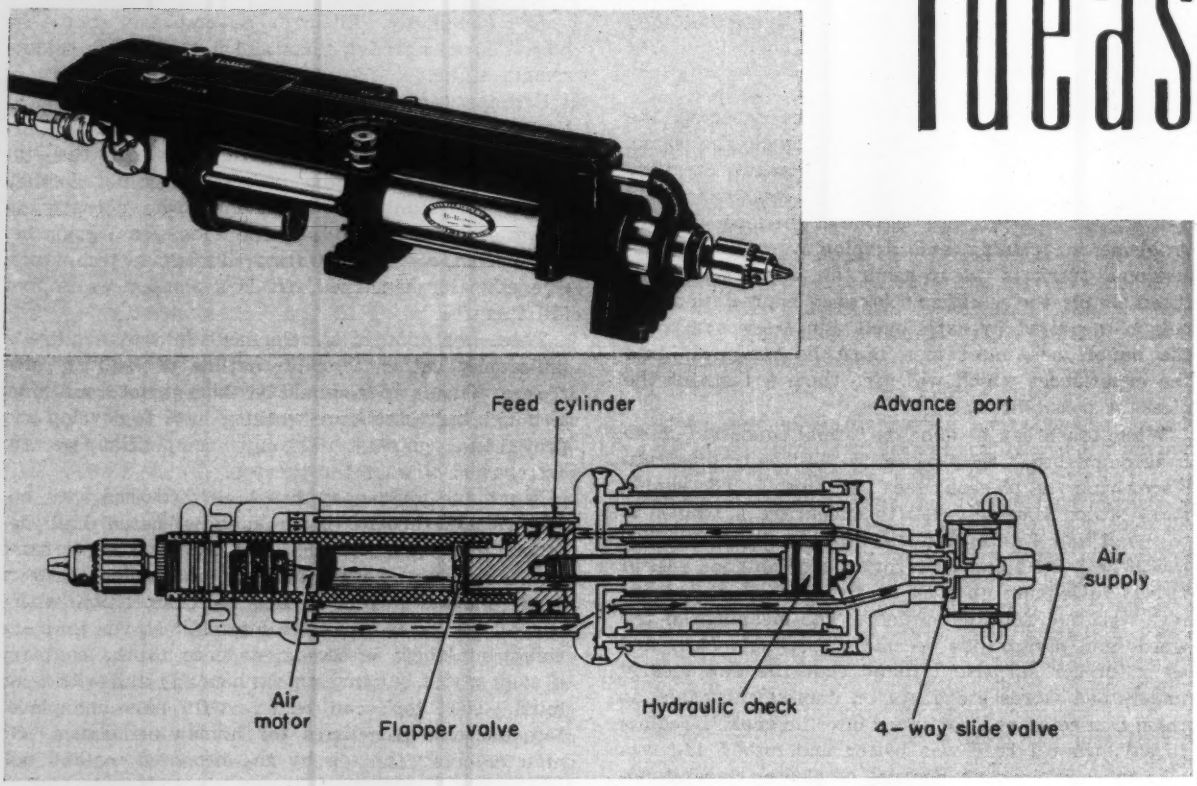
When the philosophy has been discussed with engineers and others, most have indicated high interest, even concurrence. But most of these same men find the change difficult and quickly revert to the old methods of chance and competition, where the rule is "every man for himself." Maybe they are right, but there is strong evidence to the contrary if they would but investigate honestly and with open mind. The "top" can be an awful lonesome place; too lonesome sometimes for human endurance. No man reaching the top by the proposed method will ever be lonely. He has invested himself in his fellow man and no one can rob him of his priceless fortune.

The heart of proposed method of development and training of engineers is simply "develop yourself by developing others"—a system in which everyone wins. The distinguishing characteristics of the method are the psychological effects of removing fear on the one hand and of supplying friendly and helpful support on the other hand when required.

The sustaining power of the method is supplied by everyone's natural interest in his own ideas, a case of turning a selfish interest into constructive and co-operative channels. And the beauty of the method lies in the priceless quality of its effect on man—of being able to live with himself on any rung of the ladder of success, even on the top rung.

"We in America have always been a little inclined to feel that we have a corner on mass production skills. If that were ever the case, it is certainly not so now. We are going to have to work and work hard so that nobody else will ever be able to equal our mass production skills."—E. W. RAWLINGS, *lieutenant general, U. S. Air Force*

SCANNING the Field For Ideas



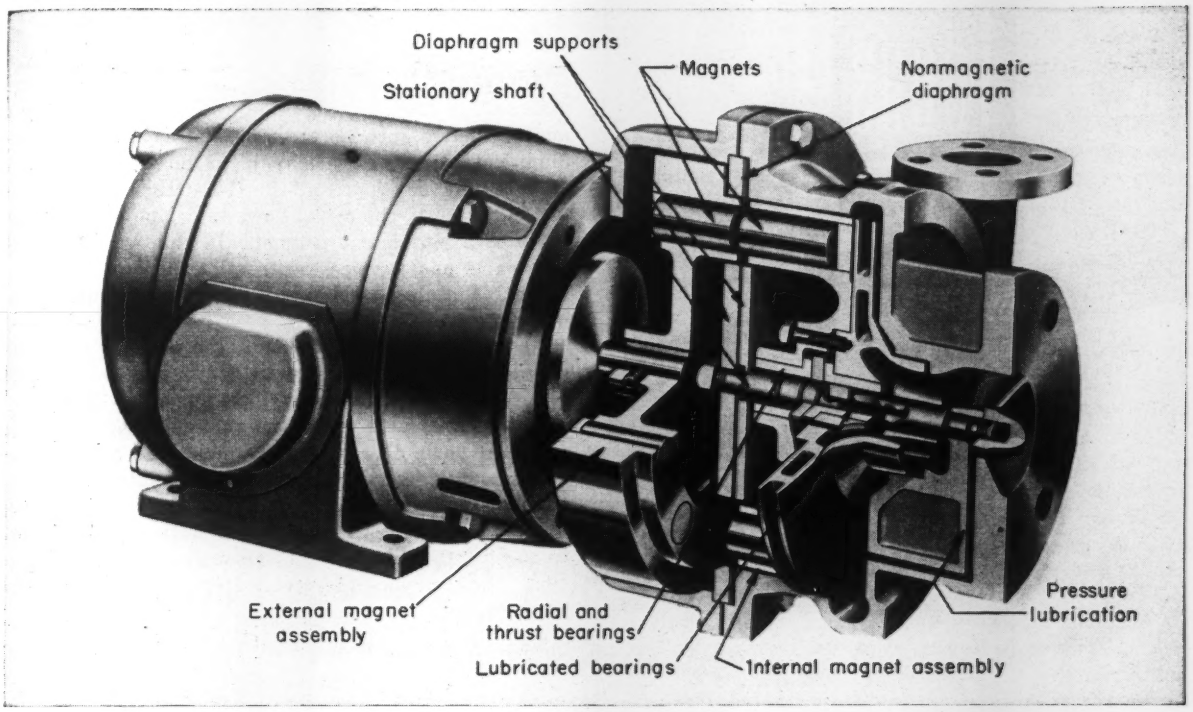
Integral controls in the power-feed drill unit, above, provides infinite regulation of feed rate and precise control of depth of feed. A compact design, this unit has an air-driven spindle and a hydraulically controlled feed rate. Operation is electrically actuated by pushbutton and limit switches. A mechanical stop or depth gage may be adjusted either for pushbutton retraction of the spindle or for automatic return by limit switch control.

Sectional drawing, above, shows the pneumatic and hydraulic circuits in this drill developed by The Bellows Co. Air supply flows into the rear of the unit through an electrically controlled valve. Flow of air is directed by this 4-way slide valve through an advance port and transfer tube into the rear of the feed cylinder, forcing the piston assembly forward and advancing the drill spindle. After a preset rapid advance a hydraulic check valve meters the transfer of oil from the hydraulic check cylinder to control the feed rate.

As the piston moves forward a flapper valve in its head opens and allows air to flow through the piston to a rotary air motor which drives the drill chuck. Exhaust from the motor is through a series of holes in its housing and exhaust from the cylinder is through transfer tubes leading back to the 4-way slide valve and out an exhaust port.

When the drill spindle is fully advanced, the 4-way valve operates to retract the feed piston. This is done by reversing the exhaust procedure when the valve shifts, allowing air line pressure to flow through the transfer tubes into the cylinder in front of the piston. Rotation of the air motor stops during the retract portion of the cycle.

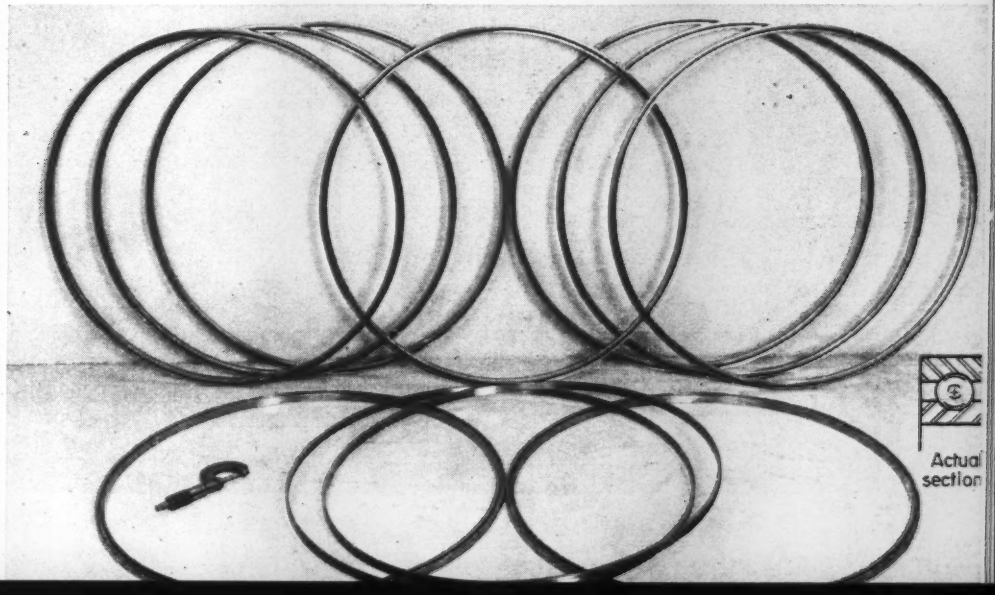
Permanent-magnet coupling drives the pump illustrated at the top of next page and requires only static seals to restrain the fluids being pumped. As shown, one set of magnets is mounted on the motor shaft and another set is attached to the pump impeller. A nonmagnetic diaphragm with static seals separates the two members of this coupling, effectively sealing the pump chamber.



Power is transmitted from the motor to the pump by the magnetic fields from adjacent opposite poles of the permanent magnets mounted around the periphery of the driving and driven elements. Relative torque of the coupling is above twice that of the motor and, after three years of service, the magnets have not been affected by aging. The driven disk and attached impeller rotate around a stationary stub shaft in the pump. Bearing lubrication is effected by liquid being pumped through the housing and the center of the stub shaft.

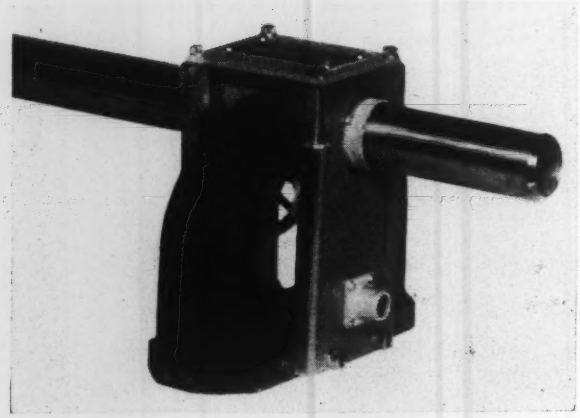
This pump unit, designed by the Peerless Pump division of Food Machinery and Chemical Corp., is an end suction, horizontal, centrifugal type with ratings up to 2 hp at 1760 rpm. Materials from which the pump is built are selected to meet the requirements of the application. Carpenter No. 20 stainless-steel, bronze-fitted cast iron and all bronze have been employed. A nonmagnetic material for the diaphragm, however, is essential. Stainless-steel or plastics are usually utilized.

Because of the self-lubricating properties of the pump bearing, only nonabrasive liquids can be pumped. Applications are expected to include processes where a closed system of liquid flow is required, where contamination of the liquid cannot be tolerated, or where leakage of the liquid is not permissible. The pump will handle hazardous, toxic or oderiferous liquids, or pump extremely hot or cold liquids as well as highly corrosive liquids.



Extremely thin ball bearings, right, conserve weight and space in the design of critical applications. These precision bearings, produced by Kaydon Engineering Corp., have an outside diameter of 17.625 inches and an inside diameter of 16.875 inches with only a 0.375-inch thickness. Such a bearing weighs about two pounds.

Ideas



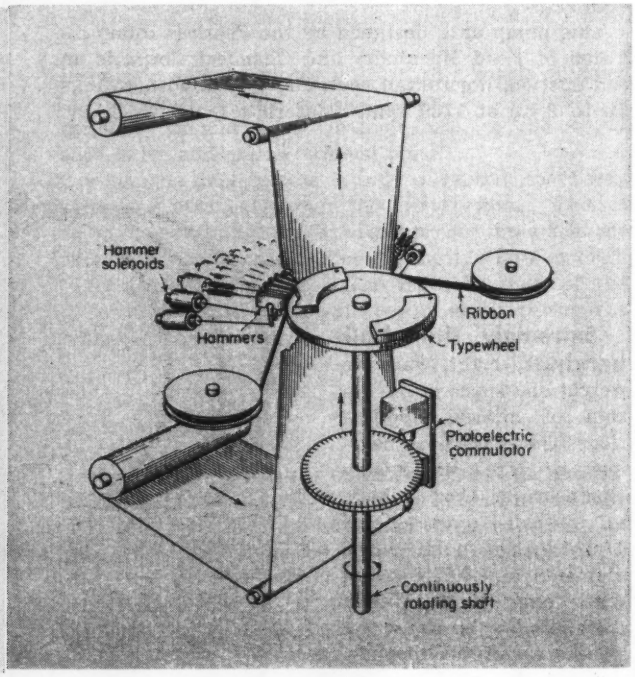
Magnetic flowmeter, left, has its sensing element external to the flowing liquid so that hazardous molten metals such as sodium, lead-bismuth, and sodium potassium alloys may be metered with safety. In this unit, developed at the G-E General Engineering Laboratory, the metal flows in a pipe between the poles of a permanent magnet. In this way all movable parts and physical obstructions to flow are eliminated. Stainless-steel supports center the pipe in the magnetic field.

As the metal flows through the pipe, it cuts the magnetic lines of flux set up by the magnet. This generates a small directional voltage in the pipe proportional to the amount of magnetic flux and the rate of metal flow. The voltage is picked up off the pipe by two stainless-steel wires and transmitted to a potentiometer type of indicating or recording instrument. Length of the stainless-steel pipe is 2½ feet to assure the required cross-sectional flow distribution. Accuracy of the meter is plus or minus three per cent.

High-speed typewriter, below, is capable of reproducing 24,000 characters per minute from a magazine of 47 characters. Designed by P. C. Michel, Potter Instrument Co., for use in computing, data handling and communications, the machine prints on a roll of paper from typewriter ribbon and hard-face type.

This machine utilizes an electronic serial-parallel storage unit which accepts information in coded pulses from an external source such as a computer, magnetic tape, punched cards, or communication lines. Eighty channels, corresponding to the characters per line, may be serial or parallel fed according to input requirements. Information is alternately stored and extracted in these channels, completing this cycle once for each cycle printed.

Type is arranged in segments on the edge of an eight-inch disk rotating at 300 rpm. Eighty ham-



mers arranged in an arc parallel to the type wheel are electromechanically impulsed at appropriate times against the type faces according to signals from the electronic storage unit. A photoelectric pulse generator on the shaft of the type wheel is used to process the characters out of storage. The system is self-synchronous and can be operated on a continuous or intermittent basis, the printing being controlled by the input of the machine.

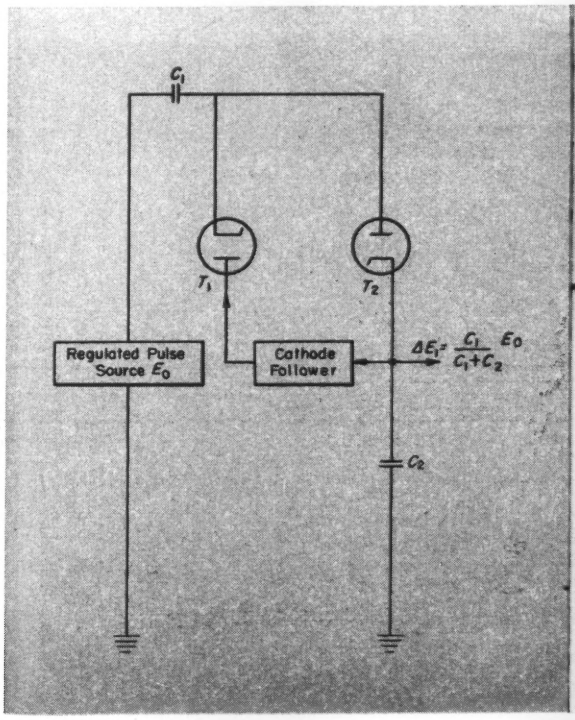
Essentially an extremely flexible shift register, the electronic storage may be employed as part of a computer to perform addition, subtraction, division, and multiplication. It may also be used to shift the information being printed to any selected columns.

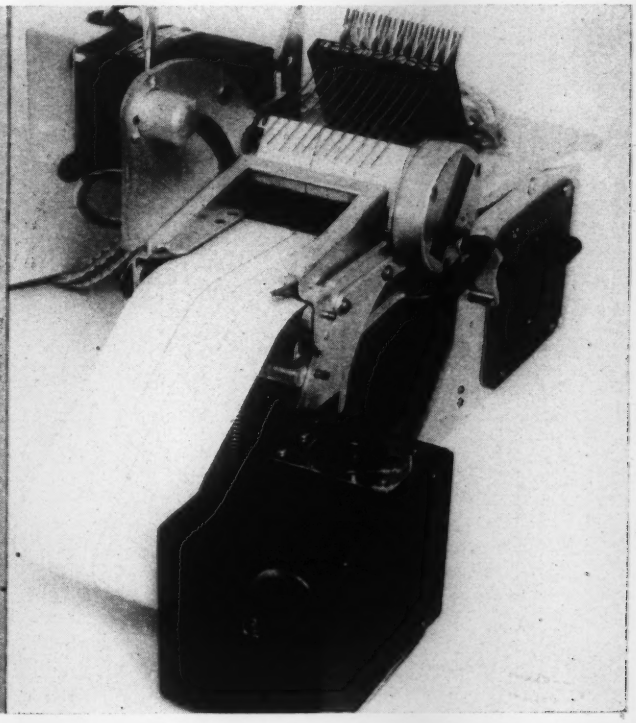
Discrete indicating or recording, below, to the nearest digit value, instead of conventional recording of a continuously variable quantity, has decided advantages in electronic systems. By obtaining a distinct coded output, the signal can be fed into a device such as a computer. Also the accuracy of reading is greatly increased. In moving pointer instruments, speed of response is usually limited by mechanical characteristics, and the accuracy to which the instrument can be read is about 0.5 per cent. In this three-digit instrument, the accuracy is 0.1 per cent of full scale and the rate of recording is 400 or more readings a second.

In the recorder, which is a modified commercial instrument, ten wire fingers press continuously against a moving strip of electrosensitive paper. Application of voltage to any of the ten wires results in a dark mark on the paper. For this particular instrument, the ten-digits are printed as a dashed line, the unit-digits as a dotted line and the tenth-digits as a solid line. The position of each line on the paper gives the value for each digit of the numerical value.

Developed by M. L. Kuder at the National Bureau of Standards electronic instrumentation laboratory, the device is called an Anodige. It employs an analog integrator circuit that charges a capacitor in equal increments until the capacitor voltage equals the unknown voltage being measured. At the beginning of each measurement, a programming oscillator energizes a master oscillator. The analog integrator starts simultaneously to build up dc voltage. This increasing voltage is fed to one side of a balance detector and the unknown voltage to be measured is applied to the other side. As soon as the voltages are equal, within the last digit, the balance detector stops the master oscillator and unblocks the counter indicator, recording the final count.

The basic integrator circuit used in the Anodige is shown schematically, below. Each time a regulated pulse is applied to the input, the voltage across the integrating capacitor is increased by the increment shown in the sketch.





FOUR-BAR LINKAGES

. . . designs are expedited by

By Josef Boehm
Mechanical Engineer
Huntsville, Ala.

RAPID and precise plotting of curves described by points on the connecting link of a four-bar linkage is of utmost importance in design. Point-by-point generation of these curves for successive crank displacements is extremely time consuming. The designer, however, must be able to trace a large number of these curves in order to select the most suitable curve by scanning a field of plotted curves with respect to their shape, relative position to the fixed link and the velocity with which the point passes through its path. By means of the curvograph instrument, *Figs.* 1 and 2, these curves may be plotted in limited time and with minimum effort[1].

Coupler Curves: The trajectories generated by

[1] References are listed at end of article.

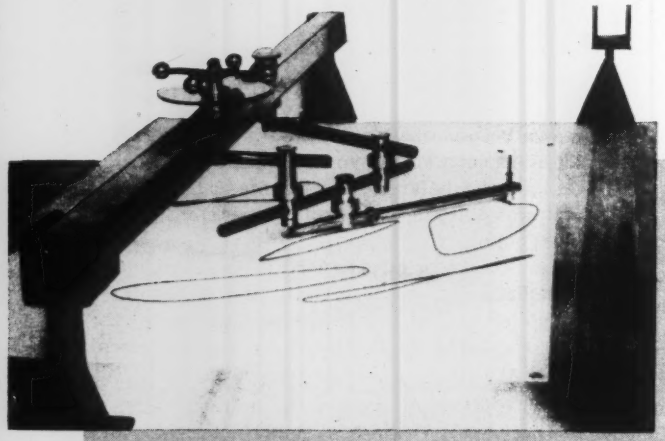
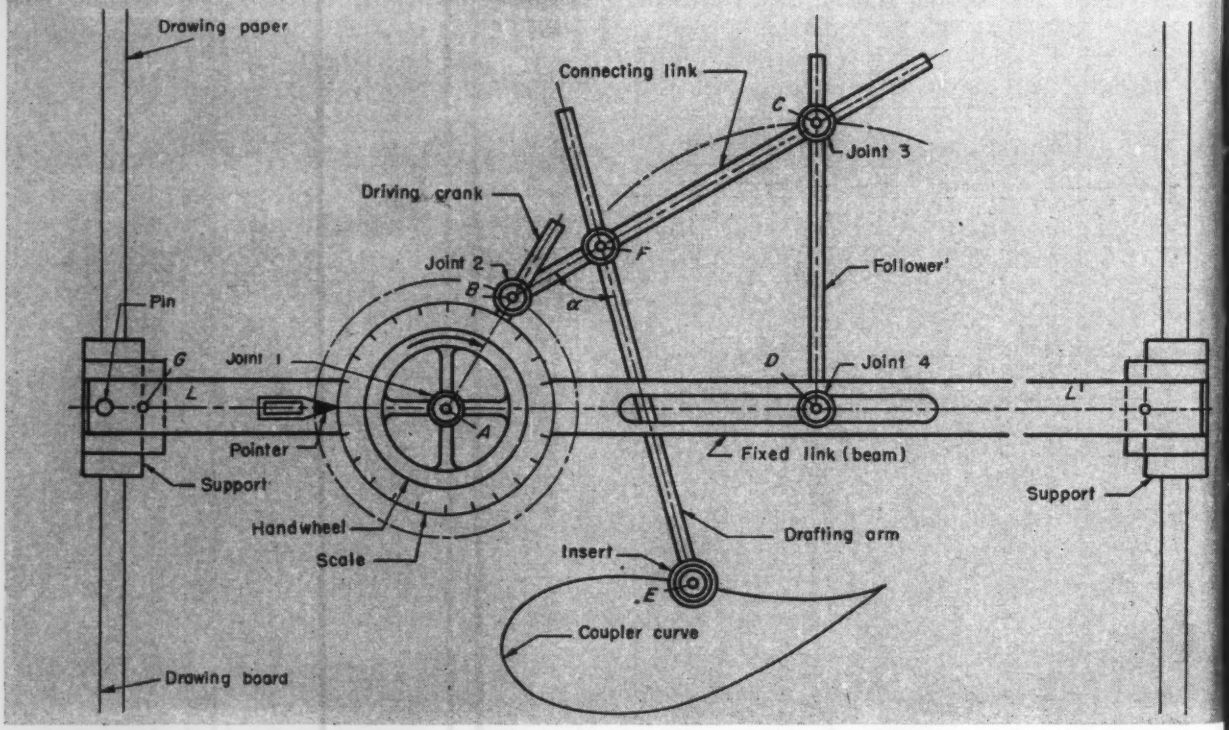


Fig. 1—Left—To facilitate the design of four-bar linkages, the curvograph has adjustable links to produce any trajectory within its capacity

Fig. 2—Below—Diagram of the curvograph showing how the beam is held in its supports and how each link is adjustable to produce desired motion



...rvograph to determine mechanism proportions

While in charge of research work for the department of kinematics at the University of Dresden, the author frequently applied linkages to mechanisms for automatic machines. Because plotting of coupler curves for four-bar linkages was a time consuming and monotonous procedure, he decided to find a better way for rapid and precise plotting. As a result of this decision, the curvograph discussed in this article was developed and has proved extremely useful

points on the connecting link of a four-bar linkage, or of more complex mechanisms, have been termed "coupler curves" and "coupler points", respectively. Originally, the equation of the coupler curve for the four-bar mechanism was derived by S. Roberts[2]. Further essential treatises on coupler curves were written by F. Ebner[3] and G. Loria[4].

The following equation of the coupler curve is obtained by placing the four-bar linkage in a rectangular co-ordinate system, *Fig.* 3, where the pivot of the crank is identical with the origin *O* and the fixed link coincides with the x axis. Thus, the general equation of the coupler curve is

$$U^2 + V^2 = W^2$$

where

$$U = b\,[(x - f)\cos\gamma + y\sin\gamma]\,(x^2 + y^2 + c^2 - r^2) - cx\,[(x - f)^2 + y^2 + b^2 - R^2]$$

$$V = b\,[(x - f)\sin\gamma - y\cos\gamma]\,(x^2 + y^2 + c^2 - r^2) + cy\,[(x - f)^2 + y^2 + b^2 - R^2]$$

$$W = 2bc\sin\gamma\,[x\,(x - f) + y^2 - fy\cot\gamma]$$

The coupler curve is a tricircular curve of the sixth degree. In *Fig.* 4 is illustrated a variety of curve shapes that can be generated by four-bar mechanisms. The curves shown in *Fig.* 4*c* and *d* have a double point (node) and those in *Fig.* 4*e* and *f* are characterized by a cusp.

Possibilities of link-drive applications are as manifold as the possible shapes of coupler curves. Link drives are employed in automatic machines such as those for wrapping, packaging, printing, weaving, vending, farming, conveying, machining, etc. Compared with cam drives, link mechanisms have positive advantages resulting from reduced wear by surface contact, improved adjustability by varying the link lengths, etc.

Principally, there are two different functions of coupler curves in link drives: (*a*) The described coupler curve is applied directly to the operation, for instance, at the operation of the catcher[5] in a mechanism for intermittent film movement, *Fig.* 5. (*b*)

Fig. 3—Four-bar linkage system in co-ordinate system has the crank at the origin and the fixed link on the *x*-axis

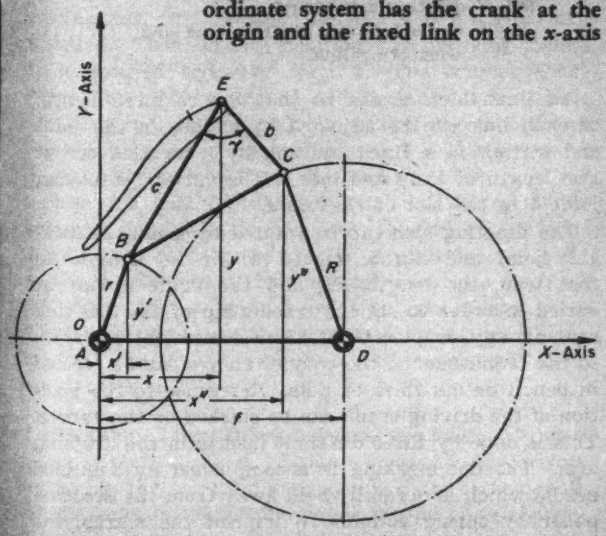
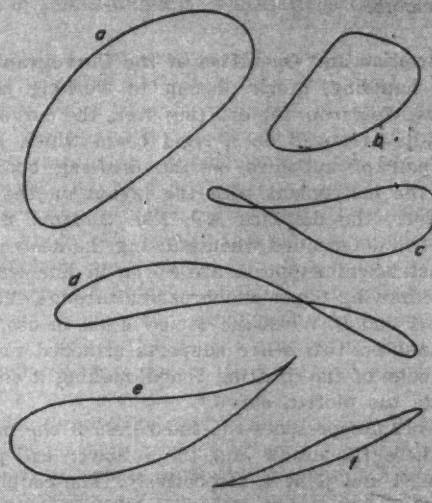


Fig. 4—Typical samples of coupler curves for four-bar linkages



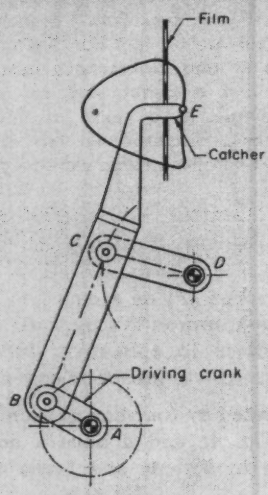
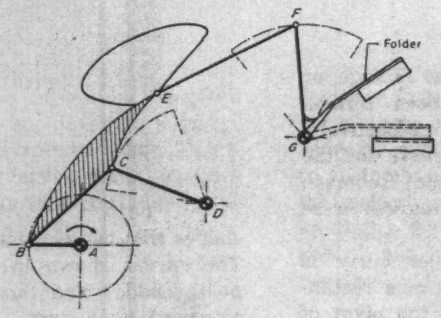


Fig. 5—Left—Mechanism for intermittent film movement designed by Askania

Fig. 6 — Below — Linkages employed to drive the folding mechanism of a wrapping machine



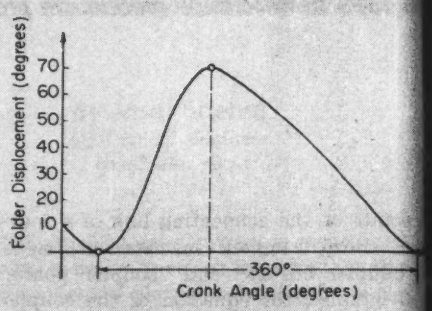


Fig. 7—Above—Displacement vs. crank angle (time) diagram. The large ratio of crank angles required the application of a six-bar mechanism

In cases where the motion of the driven link is derived from the connecting link of a four-bar mechanism, the coupler curve is applied indirectly when linking the follower by means of another coupler link to the connecting rod. An example of indirect drives is the mechanism for driving the folder in a wrapping machine, *Figs.* 6 and 7.

Occasionally, only part of a coupler curve is of interest for a given case. In *Fig.* 8, the coupler point *E* passes through only part of its path but in both directions. The represented four-bar linkage has an oscillating motion on the crank and on the follower. The required velocity of the coupler point, passing in both directions through a part of its path in a motion of steady-state, is prescribed by the displacement diagram of the crank or the follower. The crank or the follower can be driven by a cam drive or a linkage.

Description and Operation of the Curvograph: For simple handling, quick placing in working position and removing from the drafting area, the curvograph, *Fig.* 1, is arranged on a rigid beam which is held by a pair of supports on the drafting board. To orient the instrument with the layout on the drawing paper, the distance *AG*, *Fig.* 2, from the left support is determined when starting the design work. The instrument supports are set in in line with *LL'* on the drawing paper which passes through the pivot points *A* and *D*. When the device is not in use, it can be placed on two other supports attached near the upper edge of the drafting board, making it easier to evaluate the plotted curve.

The beam represents the fixed link of the mechanism where the crank and the follower are pivoted by joint 1 and joint 4, respectively. The coupler link is connected to the crank by joint 2 and the follower by joint 3. All four joints are turning pairs for the required constrained motion. The drafting arm is adjustably mounted to the connecting link.

For general use, the instrument provides variable length for all links. Thus, an infinite number of link ratios can be arranged in order to find coupler curves of a mechanism to be incorporated in the layout of a new machine or device. If an already existing linkage is used to derive a motion for an additional mechanism, the same link ratios can be verified on the curvograph. The following values of the instrument can be adjusted as desired:

AB = crank length
BC = connecting link length
CD = follower length
AD = fixed link length
EF = drafting arm length
α = angle between drafting arm and connecting link.

All links have scales so that the required length of each link can be adjusted by sliding in the joint and setting in a fixed position by a knurled screw. The length of the fixed link AD is varied by moving joint 4 in the slot of the beam.

The drafting arm can be rotated by means of lockable joint and can be moved within its mount. In that way, the length EF and the angle α can be varied in order to set the tracing tip of the drafting arm on any coupler point. For convenient adaption to the requirements, the coupler curves can be plotted in pencil or ink lines or dots. Reference to the position of the driving crank can be marked on the curves. This is done by three different inserts in the drafting arm. The dot marking is accomplished by a guided needle which is normally held away from the drafting paper by spring action. To imprint the marks, the needle is pressed down at, for instance, 10 degree successive displacements of the driving crank. A circular

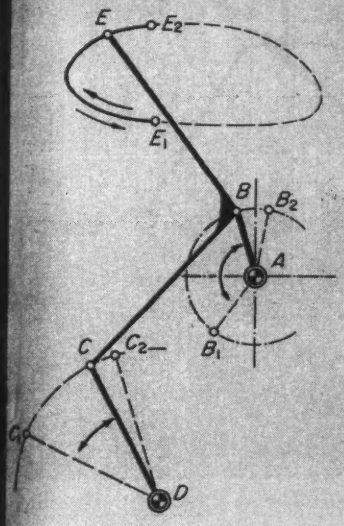


Fig. 8 — Left—Mechanism having a reciprocating motion utilizes only part of the coupler curve

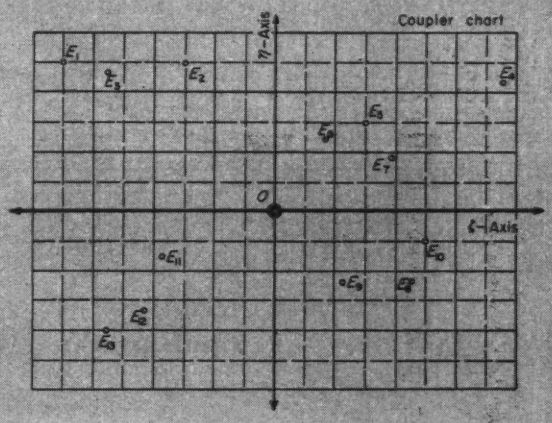


Fig. 9—Right—Coupler chart with entered coupler points

scale with 360-degree divisions is fastened directly to the crank so that any position of the crank is read by means of a pointer attached on the beam. The pin on the left working support restricts the curvograph to a definite position within the support guide with respect to the layout.

To adjust the drafting arm for plotting the path of a certain coupler point, two pointers and a so-called coupler chart assist the designer in plotting the desired curve. This chart, *Fig.* 9, represents a coordinate system with the axes ζ, η where the coupler points are to enter. The pointers are attached to the joints of the connecting link with tip of each coinciding with the corresponding joint axis. For instance, the coupler point *E* forms the path to be traced. The following procedure is employed: First, the required lengths *AB, BC, CD* and *AD* of the curvograph are adjusted. Then, in any position, the crank is locked by a knurled screw at joint 1. The coupler chart where point E_x is entered will be brought in coincidence to the coupler link by setting the tip of the pointer on joint 2 on the origin *O* and the tip of the pointer on joint 3 on the ζ axis.

Now, the locking screws of the drafting arm are loosened and the arm is moved relative to the connecting link so that the tracing tip touches point E_x on the coupler chart. In this position of the drafting arm, the locking screws are tightened again. The coupler curve is now traced in lead or ink by simply rotating the driving crank a full revolution after having loosened the lock screw at the crank.

Designing Link Drives: When verifying a given follower motion (of steady-state), one of the decisive factors in the selection and layout of the most usable mechanisms is the displacement versus time characteristics. Especially if a linkage is to be employed, it is necessary to scrutinize these characteristics with regard to the accuracy to be fulfilled. Often, it is found that only several points of the diagram need to be followed exactly while the rest of the curve permits more or less deviation. For this reason, it is suggested that the permissible tolerance area be indicated in the diagram. The smaller the part of the diagram of close verification and the broader the tolerance area, the easier and quicker the proper curve may be obtained.

Since linkage design is often a try and approach procedure, it is obvious that solving a problem will depend more on the skill and experience of the designer than solving the task by a general scientific method. The proportions of linkages with characteristics of higher requirements are often better and more exhaustively determined by the method of the kinematic synthesis. With the curvograph, the paths of coupler points found by calculations can be easily plotted.

Also, utilizing the curvograph with the results of the comprehensive study of displacement and velocity characteristics of the four-bar linkage as published by J. A. Hrones and G. L. Nelson[6] may be advantageous. Both means are supplementary to each other. The Hrones and Nelson volume gives the designer a great survey of coupler curves while the curvograph enables him to plot simply the path of any coupler point which is not contained in this survey. Thus, the approach to a solution of the task is eased essentially. Furthermore, the curvograph is advantageous because any link ratios can be adapted to the generating four-bar mechanism to suit the dimensions required by the case in question.

It is also possible to apply linkages when displacement diagrams with periods of zero displacement of the follower are given, as H. Alt[7] has pointed out. For example, in order to drive the slider in *Fig.* 10 according to the diagram of *Fig.* 11, it is necessary to

Fig. 10—Right—Six-bar linkage driving a slide with a dwell period in one end position

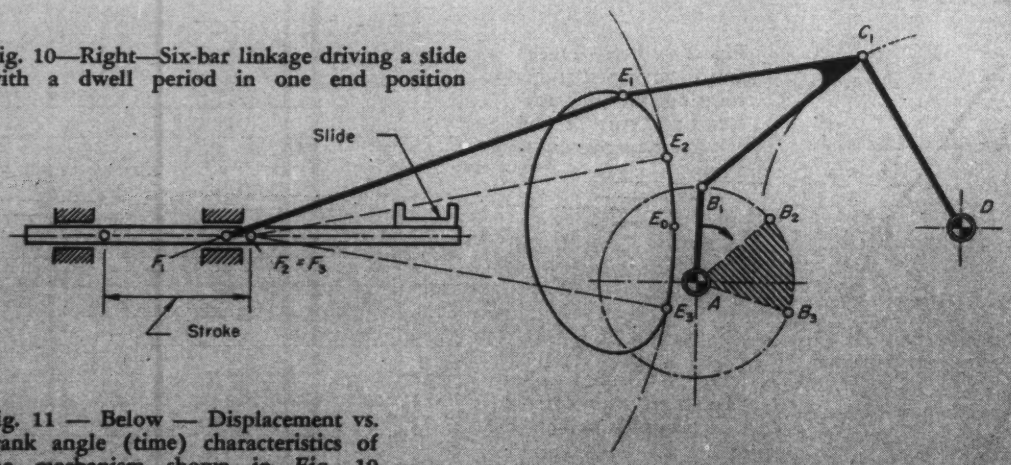
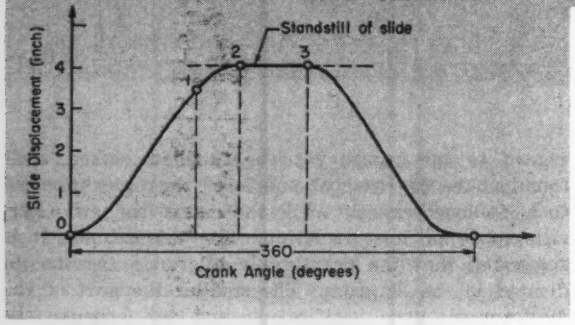


Fig. 11 — Below — Displacement vs. crank angle (time) characteristics of the mechanism shown in *Fig.* 10



locate a suitable curve which gives, at a prescribed position of the slider, a standstill of the latter. This is true when the osculating circle to the coupler curve at point E_o osculates sufficiently so that point E can be considered as moving practically on a circle with the radius EF and F_o as center of this circle. Point F_o will not move during the period indicated, that means also the slider is at standstill. The radius EF is the radius of curvature at point E_o. It is considered convenient to use the osculometer as developed by H. C. Curtis[8] for the determination of the radius of curvature. The osculometer is a device to obtain graphically the curvature at a given point of a plotted curve by comparison with a series of arcs of known curvature.

Conclusion: By using the curvograph, the plotting of coupler curves generated by four-bar linkages is simplified essentially. Because the device is composed of four links, all of variable length, any point of the infinite number of coupler points is reached by the tracing tip of the drafting arm within the area used. Intervals imprinted on the curves give information about velocity with which the coupler point passes through its path when constant angular velocity of the driving crank is assumed.

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8. H. C. Curtis—"Determination of Curvature by an Osculometer", *Journal of Research of the National Bureau of Standards,* Vol. 44, Feb. 1950, Pages 131 to 134.

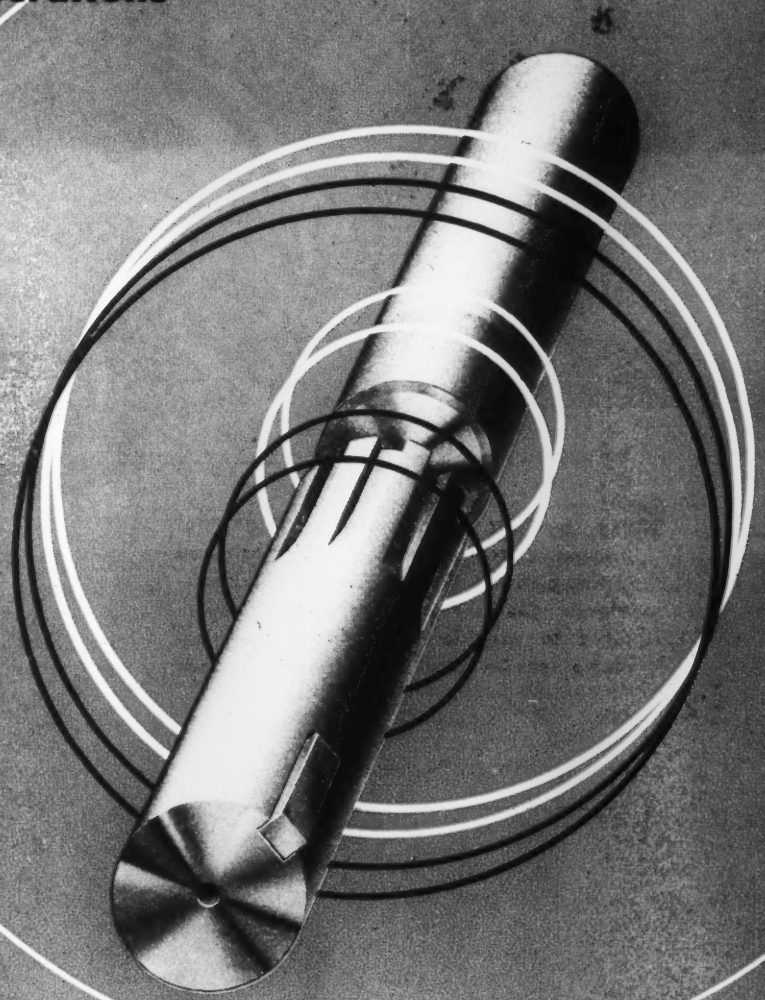
They Say . . .

"When the day comes that a company called Atomic Energy Inc. is formed to provide power for the electrical systems of this country we will be in a much better position to discuss intelligently the positive impact of atomic energy upon our economy. The fact remains that while the world ultimately looks to the atom to produce power, the atomic energy program is today the largest single *consumer* of power." —GORDON DEAN, *chairman, Atomic Energy Comm.*

"We are spending almost one per cent of our national income, or about two and one-half billion dollars annually, on research and development. We will need to increase these expenditures in the years ahead if we wish to continue to be the leader in technology. If we can maintain our defensive strength and improve our standard of living, this is a small price to pay."—DR. H. A. LEEDY, *director, Armour Research Foundation*

Clutches

Their selection and application for optimum performance requires manifold design considerations



By
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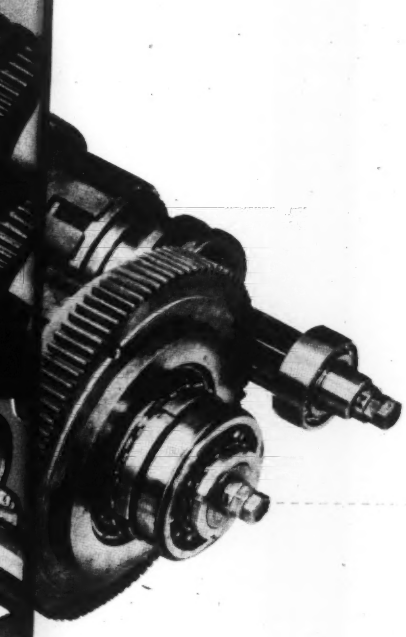
Fig. 1—Four multiple-disk machine tool friction clutches enable fast, clash-free shifting in the Gisholt turret lathe headstock. Clutches are hydraulically operated to provide quick forward or reverse spindle rotation at selective speeds

—Courtesy, Carlyle Johnson Co.

Mechanical Contact Clutches



SPECIALIZATION IN CLUTCH DESIGN and manufacturing has greatly enhanced the development of clutch engineering "know-how" and production techniques in these vital machine components. To help familiarize designers with the present status of clutch development and to aid in the selection and application of commercial units, an extensive survey of this field is presented in this article

IN MACHINES where the flow of mechanical power is controlled through clutches, efficient performance and flexibility of operation depend largely upon clutch characteristics. Currently the trend toward increased loads, higher speeds, and cyclic control impose increasingly critical requirements on these vital machine components, *Fig.* 1. Few clutches, excepting the most simple types, are designed or built today by machine manufacturers without first considering the adaptability of a commercial unit.

When confronted with the problem of selecting a clutch, machine designers usually will find one or more of the popular designs, TABLE 1, adequate and suitable. As evidenced by TABLE 2, listing representative clutch manufacturers, special attention has been devoted to the development of many clutches for various functions and forms of service.

Classified according to mode of torque transmission, three general types of clutch devices become apparent. They are: mechanical contact, magnetic flux, and hydraulic fluid. Inasmuch as the majority of clutches drive through mechanical contact, these will be considered first.

Basically, there are two types of mechanical clutches, friction and positive. The friction clutch consists essentially of two opposing friction surfaces or multiple sets thereof, one attached to a driving member and the other to a driven member. Torque is transmitted when these surfaces are forced into contact by an actuating mechanism. Properly adjusted, friction clutches will carry up to 100 per cent overload, without slip, creep, or other loss of power. They will, however, slip momentarily under shock loads, thereby providing cushioning action, and they will slip during engagement, thus permitting a load to be coupled and accelerated smoothly even though the drive may be running at high speed.

By definition, the positive clutch will not slip, up to the point of destruction. Generally speaking, for a comparable torque capacity this clutch may be smaller, lighter and less costly than a friction clutch. It is also simpler and does not require adjustment for wear. Because it does not develop heat appreciably during use, it may be cycled frequently. On the other hand, the positive clutch cannot be engaged at high speeds, although it can be run at high speeds and, depending on the circumstances, it can sometimes be disengaged at high speeds. Shock results from engagement at any speed above zero, and this is a major limitation. Another disadvantage

TABLE 1—CHARACTERISTIC FEATURES

CLUTCH DESIGN	OPERATING CHARACTERISTICS							DIMENSIO
	IDLING	ENGAGING		DRIVING				
	Drag Torque	Frequency[1] (max/hr)	Time[2] (secs)	Torque Output	Speed Control	Slip[3] (%)	Overload Release	Shaft Diameter (inches)	Extrem Diamet (inche
POSITIVE CONTACT								
Machined square jaw	Very low		1.0	Constant		0	No	$\frac{13}{16}$-5$\frac{13}{16}$	3-15
Spiral jaw	Very low		1.0	Constant		0	No	$\frac{13}{16}$-5$\frac{13}{16}$	3-15
Multiple-toothed jaw (mechanical operation)	Very low		0.1	Constant		0	Special	1¼-6½	4-14
Multiple-toothed jaw (magnetic operation)	Very low		0.1	Constant		0	No	3-6	9$\frac{5}{8}$-17$\frac{7}{8}$
Keyed engagement	Very low	(30×rpm)	0.3	Constant		0	No	1-5½	
Overload release	Low if tripped			Preset max		0	Yes	½-7⅛	3-30
FRICTIONAL CONTACT									
Internal expansion	Low to moderate	30	1.5	Constant	Inchable	0	No	1-6$\frac{7}{16}$	4$\frac{9}{16}$-26½
Expansion-contraction (Hanson type)	Moderate	15	3.0	Constant	Inchable	0	No	8-16	32½-58
Expansion-contraction (Smith-Hill type)	Low	30	4.0	Constant	Inchable	0	No	2¾-7¾	15-64
External contracting (mechanical)	Low to moderate	15	3.0	Constant	Inchable	0	No	1$\frac{9}{16}$-5½	6½-26
External contracting (pneumatic gland)	Very low	1200	1.0-6.0	Variable	Inchable	0	Yes	2½-5	24-54½
Cone				Constant	Inchable	0	No		
Single disk, all metal	Low	15	3.0	Constant		0	No	1$\frac{7}{16}$-13	7$\frac{3}{16}$-55½
Single disk, block insert	Low	60	3.0	Constant	Inchable	0	No	1¼-9⅞	5⅜-56
Single disk, fully lined	Low	60	3.0	Constant	Inchable	0	No	¾-8	4¼-44
Single disk, molded	Low	60	3.0	Constant	Inchable	0	No	¾-3	3¾-15
Multiple disk, lined	Low	30	3.0	Constant	Inchable	0	No	1$\frac{3}{16}$-9⅞	4¼-56½
Multiple disk, all metal	Low	600	1.5	Constant	Inchable	0	Special	⅞-3	2⅝-10
Multiple disk (with positive engagement)	Low	600	1.5	Constant		0	No	1⅜-2¾	3⅞-9
Screw-action disk	Low	30	6	Constant	Inchable	0	No	1¼-5$\frac{15}{16}$	7$\frac{15}{16}$-21
Multiple disk (pneumatic operation)	Low	1200	0.3-20.0	Variable	Inchable	0	Yes	1½-8	8-46¾
Multiple disk (magnetic operation)	Low	30-600	1.0-20.0	Variable	Inchable	0	Yes	¼-12½	2¾-80
Continuous slip	Adjustable			Variable	Variable	0-100	Yes	⅝-8	2⅜-27
Overload release	Maximum			Preset max		0	Yes	$\frac{5}{16}$-12	1$\frac{3}{16}$-48
V-Belt pulley	Low	400	1.5	Constant	Inchable	0	Yes	¾-1½	2$\frac{5}{16}$-5
Centrifugal	Very low	60	3.0-180.0	Variable start	Variable start	0	Yes	¾-15⅜	3$\frac{1}{16}$-38$\frac{5}{8}$
FREEWHEELING OR OVERRUNNING									
Sprag or roller	Low to moderate	Unlimited		Constant		0	No	¼-7	$\frac{13}{16}$-20¾
Single revolution roller	Very low	400	0.1	Constant		0	No	⅜-4$\frac{13}{16}$	1⅛-17½
Wrapped spring	Moderate to high	30	0.2	Constant		0	Special	½-7	2¼-20
MAGNETIC GAP									
Hysteresis	Very low	7200	0.1-1.0	Variable	Variable	0	Yes	$\frac{5}{32}$-½	1¾-5½
Eddy-current	Very low	200	5.0-300.0	Variable	Variable	1-5	Yes	$\frac{7}{16}$-4	3$\frac{31}{32}$-42
Magnetic particle	Low to high	1200 to 3600	0.1-1.0	Variable	Variable	0	Yes	⅛-2⅛	1¼-16½
HYDRAULIC FLUID									
Hydrostatic	Moderate	900	1.0	Variable	Variable	2	Yes	1-1⅞	10$\frac{1}{16}$-14
Hydrokinetic	Moderate	20	3.0-180.0	Variable start	Variable start	2-5	Yes	¾-4	8½-28¾

[1] Approximate values for optimum life, dry clutches. May be increased for wet clutches if auxiliary cooling is provided.

[2] Order of magnitude only. Actual time for full engagement depends largely upon shaft rpm, load inertia, frictional conditions and clutch rating.

[3] Normal slippage under full load at rated speed, etc. Maximum efficiency assumed. Allowance should be made for type of load and prime mover.

[4] Nominal or catalog ratings. ... be adjusted for specific ... tions according to clutch ... factors listed in TABLE 4.

OMMERCIALLY AVAILABLE CLUTCHES

CAPACITY RANGES			COST FACTORS		COMMENTARY	MANUFACTURERS[8]
Unit Weight (lb)	Rated Capacity[4] (hp/100 rpm)	Maximum Speed[5] (rpm)	Relative List Price[6]	Service Durability Rating[7]		
10-525	1-260	.....	1.5	Good	Running engagement possible, 2-10 rpm. Capacity rating based on shaft size	14, 21, 26, 42, 43, 48, 53, 60, 64, 81,86
10-525	1-260	.....	1.5	Fair	Running engagement possible, 20-150 rpm. Capacity rating based on shaft size	14, 21, 26, 43, 48, 53, 60, 64, 86
.....	.....	.....	4.0	Excellent	Running engagement possible, 65-300 rpm. Capacity rating based on shaft size	8, 36, 80
110-550	38-305	2000-1100	6.0	Excellent	Requires dc power, stationary engagement	18, 68
.....	0.5- . .	.....	2.0	Very good	Running engagement possible, 85-300 rpm. Sensitive control, locked cycle	Possible source; power press manufacturers
3-1150	0.12-200	4000-450	4.0-8.0	Good	Sensitive to high inertia starting and shock loads. Some types unidirectional	2, 20, 39, 58, 59, 63
15- . .	0.5-125	1800-	1.5	Good	Compact, good heat dissipation	3, 10, 12, 16, 25, 37, 51, 60, 82
.....	175-1550	300-150	1.5	Good	Very high capacity, low speeds only. Slow heat dissipation	37
85-4300	9-480	1400-300	4.0	Very good	Complex, heavy construction. Slow heat dissipation	53
.....	1-50	750-150	1.5	Good	Simple construction, slow heat dissipation	16
.....	75-560	1600-900	8.0	Excellent	Cushioned engagement, also in expanding type. Elements available separately	31, 56
.....	.....	.....	Low	Good	Simple to produce. Cone angle and alignment highly critical	Not a standard commercial item
.....	2-660	1200-300	2.0	Fair	Must be lubricated, subject to sparking	44, 57
20-	1.3-240	1900-350	3.0	Very good	Long-wearing heavy-duty construction	21, 54, 60
6-2100	0.14-175	3000-625	2.0	Very good	Wearing area greatest in cemented lining construction	7, 10, 12, 16, 25, 37, 44, 48, 57, 60, 67, 73, 81, 86
5-	0.14-10	3000-1250	1.5	Very good	Lining replacement simple. Shock resistance limited	12, 16, 20, 21, 25, 73
.....	1-480	3000-350	1.3	Very good	Higher capacity but slower acting than lined single-disk clutch	4, 16, 21, 25, 34, 41, 54, 57, 73, 83, 86
.....	0.25-24	4000-900	2.5	Excellent	Very high capacity for size. Available for wet or dry operation	7, 12, 37, 44, 73
27-85	0.4-5	500-500	4.0	Excellent	Slip-free driving when fully engaged	7
45-500	2.5-55	2000-700	2.5	Very good	Slow smooth engagement affords close control of load acceleration	40
32-2400	4-1325	2000-625	8.0	Excellent	Capable of flexible remote control in severe-duty applications	6, 11, 15, 41, 61, 73, 74, 84
5-14900	0.007-2670	3600-345	5.0-10.0	Very good	Requires dc power. 7000:1 amplification of input wattage	17, 23, 68, 79
3-1350	.....	1800-700	10.0-20.0	.....	Ratings range from 0.034 hp @ 1800 rpm to 8.5 hp @ 700 rpm	29, 40
0.4-3950	0.0018-1600	1800-450	2.0	Excellent	Cushions starting and shock loads. Prolonged slippage should be avoided	12, 16, 29, 30, 33, 37, 39, 40, 51
1¼-9	0.05-0.2	3600-3600	1.5	Very good	Slippage under load comparable to normal V-belt creep	70, 76
2- . .	.....	3600-600	4.0	Excellent	Ratings range from 0.17 hp @ 1800 rpm to 7820 hp@600 rpm. Self-controlled	5, 13, 16, 19, 28, 32, 38, 50, 51, 65, 69, 77
0.1-2000	0.016-680	18,000-700	5.0-10.0	Very good	Low backlash, quick response to speed changes	9, 30 (backstop), 39, 40, 55, 75, 85
1-600	0.05-176	800-65	3.5	Excellent	Also available with fractional revolution control	40
1½- .	0.12-410	3600-900	0.5	Excellent	Capacity high for size, quiet operation. High backlash windup	39, 47, 52
.....	0.0006-0.03	10,000-5000	15.0	Excellent	Requires dc power. 15:1 amplification of input wattage	23
3- . .	0.013-130	4000-1200	15.0	Excellent	Requires dc power. 600:1 amplification of input wattage	24, 27
¼-385	0.0016-8.5	1725-2000	15.0	Very good	Requires dc power. 100:1 to 2000:1 amplification of input wattage	22, 23, 24, 35, 46, 62, 78
75-160	0.9-2	1800-1800	6.0	Excellent	Slip sensitive to oil viscosity changes	71
14-420	.....	4000-950	10.0	Excellent	Ratings range from ¾-hp @ 1700 rpm to 200 hp @ 850 rpm	1, 49, 73

...mate limits of standard de... Speed for smallest size list... first. Can sometimes be in... by special balancing if ...ting mechanism is unaffected.

[4] For equivalent horsepower capacity. Order of magnitude comparison only; depends largely upon special or combined features built into clutch.

[7] Ratings apply up to point of replacement of lining or reconditioning of worn engagement surfaces. Governed largely by frequency of operation.

[8] Key numbers represent manufacturers listed alphabetically in Table 2. Excepting automotive clutch specialists, most clutch producers are listed.

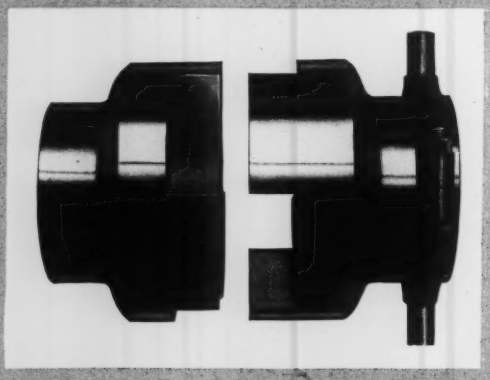
lies in the fact that positive clutches cannot always be engaged when both drive and load are completely at rest; some relative motion usually is required to mesh the parts.

Because of engagement limitations, positive clutches are not used as commonly as friction clutches; however, they do have some very important applications. For example, positive clutches are used in many special synchronized drives such as rolling mill screwdowns. They are used extensively in fractional-horsepower sizes in machine tools, business machines, and household appliances. In integral horsepower sizes they are employed in power presses, construction machinery and in most automotive transmissions.

Positive Clutches: The design and operation of a positive clutch center around its engaging surfaces. In one large group of clutches, these surfaces are gear teeth, variously modified. These teeth may be quite fine for minimum delay in engagement or coarse for maximum strength. The square jaw, or "claw" clutch, *Fig.* 2, is one of the oldest types of design. Originally it was employed with jaw surfaces in the as-cast condition. A liberal clearance between surfaces was necessary to provide for casting tolerances and to assure free meshing of the jaws; for instance, about $\frac{1}{4}$-in. space would be allowed in a clutch of 4-in. outside diameter.

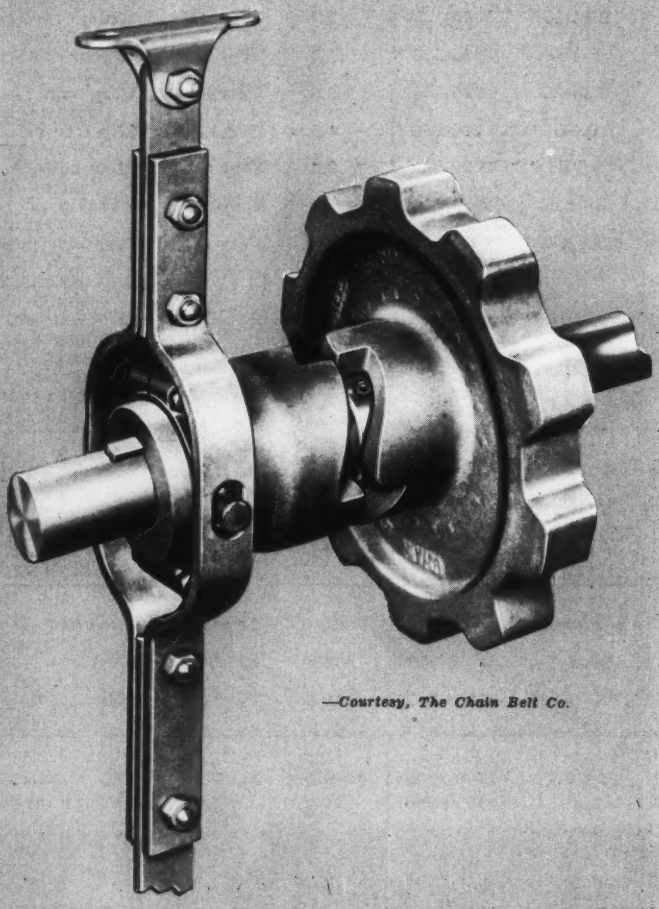
The cast square-jaw clutch offers utter simplicity of design and low cost; notwithstanding, it is used conservatively today because it cannot be engaged safely while moving. To illustrate this point, if the 4-in. clutch mentioned were to be engaged at a speed of 60 rpm, the $\frac{1}{4}$-in. jaw clearance would allow the operator 0.03-second to shift the jaws together before contact took place. Especially in view of the rough jaw faces, the likelihood would be that only a partial shift could be accomplished, resulting in destruction of the jaw tips by shock loading.

The first solution to this problem was the development of the spiral jaw clutch, *Fig.* 3. The 3-jaw design illustrated allows up to one-third of a second for shift action when running at 60 rpm. This has been found practical. Incidentally, disengagement requirements should also be considered. If the clutch is to be disengaged while running under load, finished jaws should be specified rather than as-cast, and lubrication should be provided to minimize jaw friction.



—Courtesy, The Medart Co.

Fig. 2—Above—traditional square-jaw positive clutch for bidirectional operation. The sliding half is fitted with a feather key. For its size, this clutch has high capacity



—Courtesy, The Chain Belt Co.

Fig. 3—Right—Traditional spiral-jaw clutch with integral sprocket. The sliding jaw is fitted with a feather key. This type clutch will drive in one direction only and must be specified according to rotational requirement

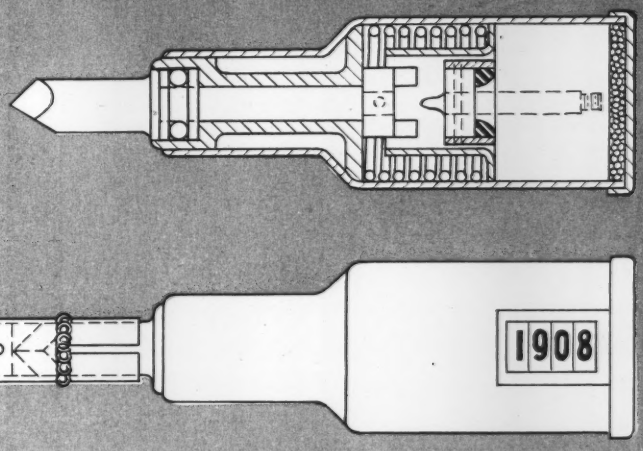
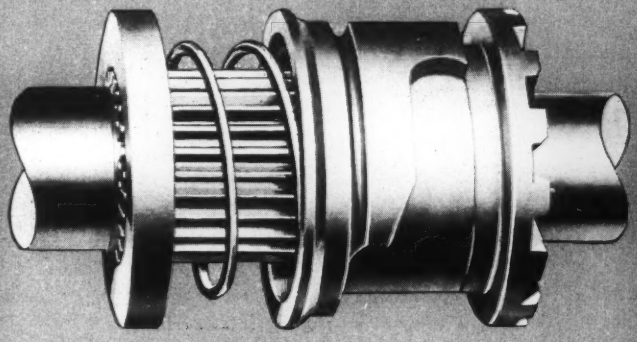


Fig. 4—Right—Wide-clearance jaw clutch in a shaft rpm counter assures accurate speed indication. Low inertia of the driven mechanism permits safe engagement at high speed

—Courtesy, Veeder-Root Inc.

—Courtesy, Niagara Machine & Tool Works



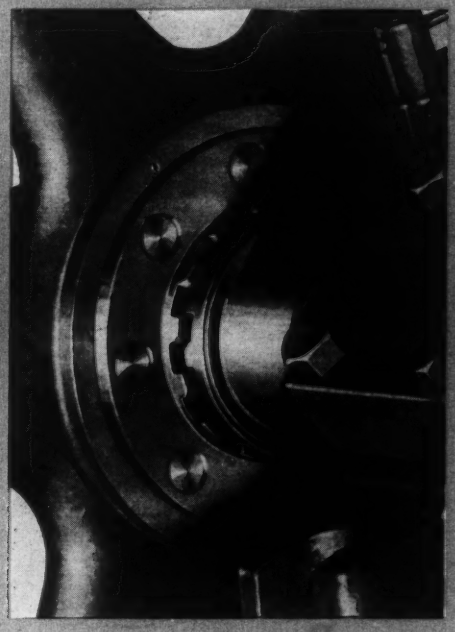


Fig. 5—The multiple-tooth jaw clutch is well adapted for heavy-duty service on power presses and squaring shears. To operate, a control roller is lifted from the throwout cam groove permitting the helical spring to slide the clutch sleeve into engagement. Backs of the teeth are tapered and relieved to facilitate engagement

The spiral-jaw clutch, obviously, will drive in one direction only. So for cases where bidirectional operation is required, several other solutions to the problem of easy engagement have been developed. Where backlash is not objectionable, satisfactory results have been achieved with a modified square jaw clutch, *Fig.* 4. The jaws are reduced to mere lugs to provide a high percentage of free space between, and the corners are chamfered heavily. Such clutches are used commonly in domestic washing machine wringer drives and ironer roll drives. The cost of these clutches is low, especially when a gear or sprocket hub can be machined to serve as one half of the clutch. Wide-clearance jaw clutches as described are not standard power transmission components. However, a low-cost common jaw-type flexible coupling can often be adapted for satisfactory clutch service on a light, low-speed drive simply by omitting the nonmetallic spider and machining a shifting groove in one hub.

Jaw clutches are now being employed in the main drive of power presses and shears, *Fig.* 5. The tooth design, however, is different from the simple jaw clutch because of special requirements. First, many teeth are needed, to provide long life plus minimum time lag between triggering of the clutch and pick-up of the load. Second, since backlash is not permissible between flywheel and crankshaft, the clear-

Table 2—Industrial Clutch Manufacturers*

1. American Blower Corp. — Detroit 32, Mich.
2. Anchor Steel & Conveyor Co. — Detroit 7, Mich.
3. Arnolt Corp., Motor Div. — Warsaw, Ind.
4. Auto Specialties Mfg. Co. — St. Joseph, Mich.
5. Automatic Steel Products, Mercury Clutch Div. — Canton 6, Ohio
6. Bliss, E. W., Co. — Canton, Ohio
7. Borg-Warner Corp., Rockford Clutch Div. — Rockford Ill.
8. Boston Gear Works — Quincy 71, Mass.
9. Bradway, C. P., Machine Works — Stafford Springs, Conn.
10. Brown Engineering Co. — Reading, Pa.
11. Cardwell Mfg. Co. Inc., Clutch Div. — Wichita, Kan.
12. Carlyle Johnson Machine Co. — Manchester, Conn.
13. Centric Clutch Co. — Woodbridge, N. J.
14. Chain Belt Co. — Milwaukee 4, Wis.
15. Clearing Machine Corp. — Chicago 38, Ill.
16. Conway Clutch Co. — Cincinnati 25, Ohio
17. Cutler-Hammer Inc. — Milwaukee 1, Wis.
19. Dodge & Stevens Inc. — Rockford, Ill.
20. Dodge, A. Y., Co. — Rockford, Ill.
21. Dodge Mfg. Corp. — Mishawaka, Ind.
22. Drive-All Mfg. Co. — Detroit 14, Mich.
23. Duncan & Bayley — Buffalo 7, N. Y.
24. Dynamatic Corp. — Kenosha, Wis.
25. Edgemont Machine Co. — Dayton 1, Ohio
26. Ehrsam, J. B., & Sons Mfg. Co. — Enterprise, Kan.
27. Electric Machinery Mfg. Corp. — Minneapolis 13, Minn.
28. Elgin Sweeper Co., Clutch Div. — 6 Oak St., Elgin, Ill.
29. Entwistle, James L., Co. — Pawtucket, R. I.
30. Falk Corp. — Milwaukee 8, Wis.
31. Fawick Airflex Co. Inc. — Cleveland 11, Ohio
32. Federal Seal & Gear Corp. — Kendalville, Ind.
33. Flaton Machine Works — St. Louis 11, Mo.
34. Funk Aircraft Co. — Coffeyville, Kan.
35. General Electric Co. (Apparatus Dept.) — Schenectady 5, N. Y.
36. Gleason Works — Rochester 3, N. Y.
37. Hanson Clutch & Machinery Co. — Tiffin, Ohio
38. Hardinge Co. Inc. — York, Pa.
39. High Precision Inc. — Hamden, Conn.
40. Hilliard Corp. — Elmira, N. Y.
41. Industrial Clutch Corp. — Waukesha, Wis.
42. Industrial Machine & Gear Works — Brooklyn 4, N. Y.
43. Jeffrey Mfg. Co. — Columbus 16, Ohio
44. Kinney Mfg. Co. — Boston 30, Mass.
45. La Belle Industries Inc. — Oconomowoc, Wis.
46. Lear Inc. — Grand Rapids, Mich.
47. L.G.S. Spring Clutch Corp. — Indianapolis 6, Ind.
48. Link Belt Co. — Chicago 1, Ill.
49. Liquid Drive Corp. — Holly, Mich.
50. Lowther, Harry A., Co. — Joliet, Ill.
51. Madden, J. P. — Bethlehem, Pa.
52. Marquette Metal Products — Cleveland 10, Ohio
53. Medart Co., The — St. Louis 18, Mo.
54. Moore & White Co., The — Philadelphia 32, Pa.
55. Morse Chain Co. — Detroit 8, Mich.
56. National Supply Co. — Torrance, Calif.
57. Newton Clutch Co. — West Newton, Mass.
58. Overload Control Co. — Glenn Oaks, L. I., N. Y.
59. Overload Release Clutch Co. — Newark 2, N. J.
60. Palmer-Bee Co. — Detroit 12, Mich.
61. Power Presses Inc. — Cleveland 13, Ohio
62. Raymond Engineering Laboratory Inc. — Middletown, Conn.
63. Rocklin Mfg. Co. — Sioux City 7, Iowa
64. Royersford Foundry & Machine Co. — Royersford, Pa.
65. Salsbury Corp. — Los Angeles 1, Calif.
66. Snow-Nabstedt Gear Corp. — Hamden, Conn.
67. Spicer Mfg. Div. of Dana Corp. — Toledo 1, Ohio
68. Sterns Magnetic Mfg. Co. — Milwaukee 46, Wis.
69. Supergear Drive Corp. — Chicago 6, Ill.
70. Tann Corp., Congress Drives Div. — Detroit 34, Mich.
71. Thomas Hydraulic Speed Controls Inc. — Wichita 12, Kan.
72. Torcon Corp. — Ashtabula, Ohio
73. Twin Disc Clutch Co. — Racine, Wis.
74. Unit Rig & Equipment Co. — Tulsa, Okla.
75. Universal Gear Corp. — 1452 E. 19th St., Indianapolis, Ind.
76. V-Belt Clutch Co. — Los Angeles 4, Calif.
77. V-Plex Clutch Div., Light Inspection Car Works — Hagerstown, Ind.
78. Vickers Electric Div., Vickers Inc. — St. Louis 3, Mo.
79. Warner Electric Brake Mfg. Co. — Beloit, Wis.
80. Waterbury Farrel Foundry & Machine Co. — Waterbury 86, Conn.
81. Webster Mfg. Inc. — Tiffin, Ohio
82. West End Machine Shop — 1403 Brown St., Wilmington, Del.
83. Western Gear Works — Lynwood, Calif.
84. Wichita Falls Foundry & Machine Co. — Wichita Falls, Tex.
85. Wonway Clutch Co. — La Grange, Ill.
86. Wood's, T. B., Sons Co. — Chambersburg, Pa.

* Numerical listing is keyed to Table 1.

ance and time necessary for engagement are obtained by heavily chamfering the backs of the teeth. Relative tooth velocities are high compared with some of the previously discussed designs. However, since a spring snaps the sliding jaw into engagement, much faster operation can be assured than is possible through manual control.

When multiple-jaw clutches are to be disengaged while under full load, as is not the case with power presses, the shifting force to disengage may become excessive. This condition may be partially offset by machining the driving surfaces at an angle with the shaft axis, producing a trapezoidal tooth. The angle required depends largely upon the character of the load. In general, a clutch tooth pressure angle of 10 degrees will hold engagement satisfactorily under steady, nonpulsing loads. This pressure angle is used in the timer clutch shown in *Fig.* 6. When a clutch is subject to moderate vibration from driver or load, an angle of from 3 to 5 degrees is considered preferable. Where shock loads are anticipated, angular driving faces are not used except in some forms of pneumatically or magnetically operated clutches which maintain engagement through force, as in *Fig.* 7.

If the jaw angle is increased to 30 degrees or 45 degrees and a spring is provided to keep the jaw halves together, an effective overload safety clutch results. The torque capacity is easily regulated by adjusting the spring load. Regarding the pressure angle, a 30-degree angle permits the use of a lighter spring than does 45 degrees but is somewhat more affected by variations in the coefficient of friction.

The nominal torque capacity of jaw clutches may be computed as a function of mean tooth radius, number of teeth, and tooth shear, bending, or crushing strength, whichever is most critical. If engagement occurs at any appreciable speed, however, the limiting factor is no longer the normally transmitted torque but rather the inertia forces set up during engagement. Mass of the driven mechanism, therefore, is to be regarded in selecting a clutch. Typifying lightweight construction in this sense, a maximum of 2500 rpm is specified by the manufacturer of the counter clutch, *Fig.* 4.

Positive clutch engagement sometimes is desired at high speeds but under no external load. Synchronization of the jaws or teeth is then accomplished effectively by means of a small friction clutch, as in the automotive synchromesh transmissions. In such a combination, the friction clutch is engaged first by the movement of the shift lever, then is disengaged with further movement, so that the positive clutch teeth may rotate into alignment. Similar in principle, a heavy-duty combination multiple disk and jaw clutch is available commercially for industrial applications requiring smooth, high-speed pick-up of a dead load

Fig. 6—Below—Serrated face clutch shifted by solenoid operation permits instant start and reset of an industrial control timer and assures nonslip drive. To minimize engagement lag, a large number of teeth is provided

—Courtesy, Eagle Signal Corp.

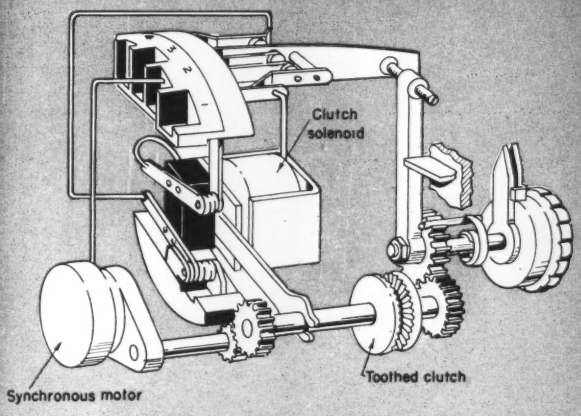
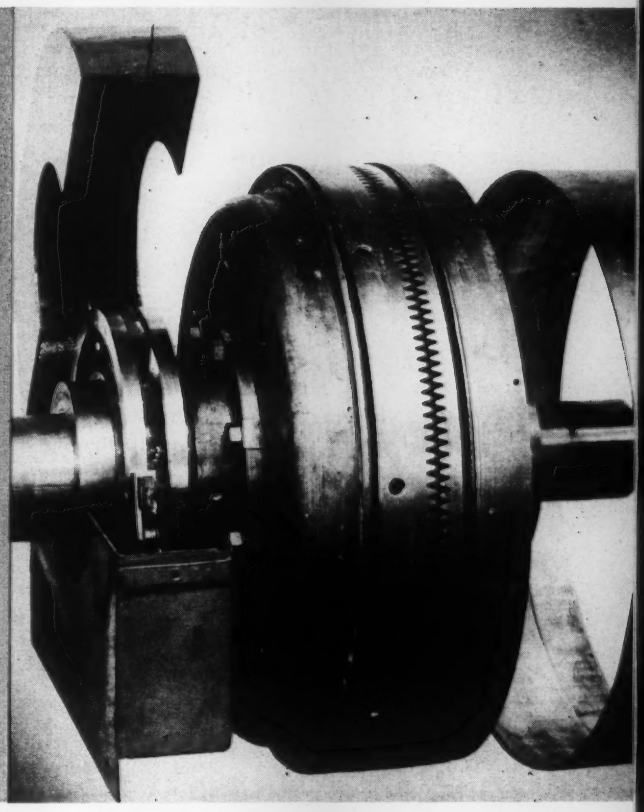


Fig. 7 — Right — Positive magnetically operated clutch for heavy-duty, slip-free driving at low or high speeds. Energizing current is conducted to coil through collector ring assembly

—Courtesy, Dings Magnetic Separator Co.



with the assurance of slip-free driving despite shock loading.

The positive clutches discussed thus far can be classified primarily as jaw or face gear types. In automotive work, internal and external gear elements are commonly used in telescopic engagement, *Fig.* 8. Whenever appreciable mass and speed are involved, this multitooth internal gear arrangement is advantageous in that it provides liberal shock load distribution and ready engagement.

Another type of positive clutch employs shiftable keys or pins for engagement. In its simplest form this clutch consists of two disks, keyed intermittently by a sliding pin near the periphery. *Fig.* 9 illustrates a development of this principle, and is called a sliding key clutch. Variously modified, this clutch has been used successfully for over a century in power presses. Because of its simplicity, it remains predominant in the light press field (roughly up to 88 tons capacity) where maintenance has been found reasonable despite the shock-action start. The sliding key must of course be replaced occasionally, as must be the hardened insert plugs, or "striking" and "rebound" pins in the flywheel hub.

Somewhat smoother action is achieved in the rolling key clutch, *Fig.* 10. This is a consequence of the low speed of engagement resulting from the rolling action and the comparatively short radial distance between the key and shaft axes. The rolling key clutch also offers long life due to the large bearing areas and distributed loads. It is used in presses up to 110 tons capacity. In considering these positive-cycle clutches, it should be understood that once they are tripped, most mechanically-operated designs must continue through a full cycle before disengagement. Without proper safeguard, the effect is to endanger the machine and the operator, particularly when the presses are hand-fed. Predominant among the various devices that have been developed to help rectify this situation are built-in single-stroke controls. These automatically disengage the clutch after each stroke and require the operator to reset the foot pedal and press down again before the press will recycle. The operator is thereby protected against an unexpected second stroke.

Positive clutch action sometimes is obtained in a drive through brake action applied to the ring gear of a planetary gear train. This arrangement is employed in the timer drive shown in *Fig.* 11. In operation, the sun gear input shaft rotates continuously. While the brake or pawl is released, the timer mechanism (not shown) may be reset and backlash is taken up automatically on the driving side of the gear teeth. Thus controlled, normal backlash in the gear train does not affect the accuracy of the timer.

POSITIVE OVERLOAD-RELEASE CLUTCHES: Frequently it is desirable to limit the amount of torque that can be transmitted from a motor to a machine in the event of an emergency. The excess torque derives largely from the inertia of the relatively high-speed

Fig. 8 — Right — Multiple key or spline clutches provide positive engagement in many automotive transmissions. Splined sleeves are positioned by manually operated shifter forks enabling ratio gears to run in constant mesh

—Courtesy, Fuller Mfg. Co.

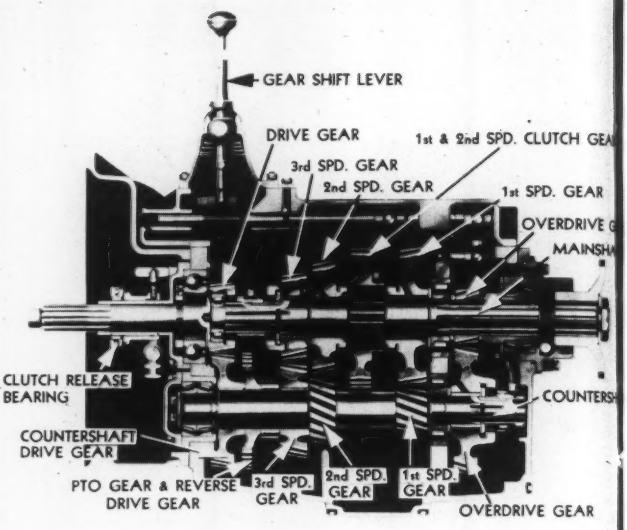
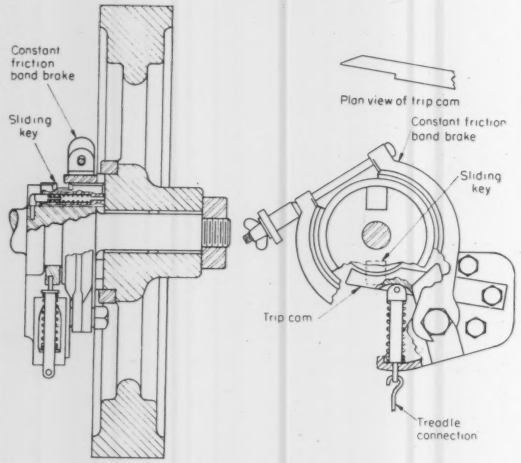


Fig. 9—Below—Conventional power press sliding key clutch; shown driving at left, released at right. Treadle operation lowers a trip cam permitting the key to be shifted by its spring against the flywheel hub. Driving starts when the key enters one of two grooves 180 degrees apart. To stop the press, the treadle is released, allowing the trip cam to be lifted to its original position by a spring. The tapered nose of the cam is then in position to enter the throwout notch in the sliding key and retract it from the flywheel



—Courtesy, Waterbury Farrel Foundry & Machine Co.

motor armature, and protection cannot be secured by an electrical trip relay. However, an instant-acting mechanical "fuse" in the machine drive between driving and driven elements will prevent damage in the event of sudden overload.

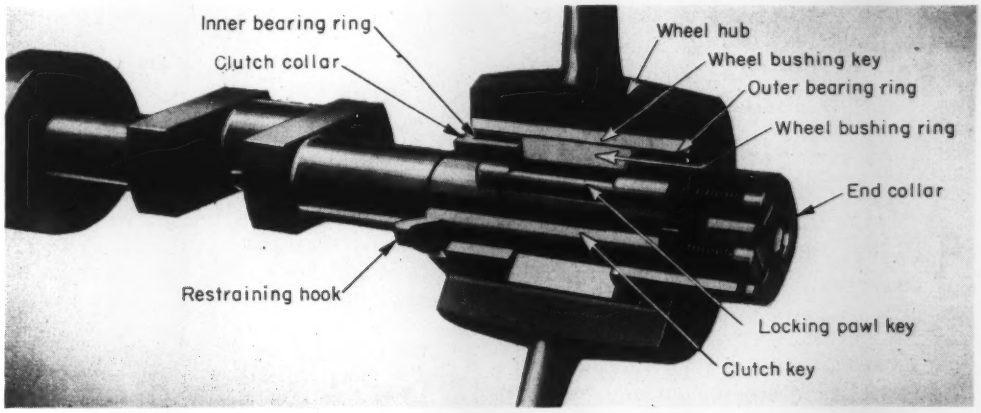
Overload-release devices not only are used to protect against the unexpected, but also are installed in devices which must drive accurately to a fixed point such as in motor-operated doors, lathe carriage drives, and power screwdrivers. Still another application is in certain timing devices, where the slip clutch permits altering the cycle while in progress.

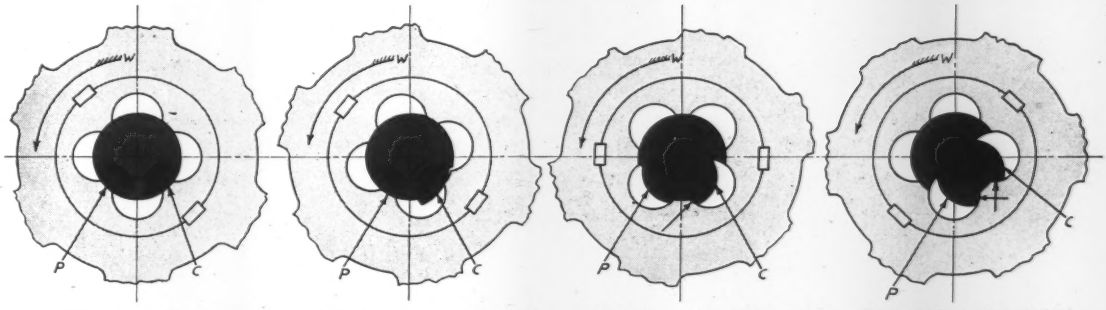
Spring-loaded positive jaw or detent-type clutches often are used in preference to a simple shear pin, where a definite angular relationship is required. There are a number of standard commercial designs of positive-type overload release clutches commercially available.

Certain of the common positive clutches continue contact while slipping. The resultant rattle is considered a desirable signal in power screwdrivers and certain other machines, *Fig.* 12. For this form of service the clutch parts should be of ample size and hardened to withstand the hammering action. To minimize wear of a slip clutch on a conveyor or other machine not closely attended, it is helpful to provide an automatic shut-off. To prevent hammering altogether, some clutches are designed to stay out of engagement once tripped. While the latter arrangement has certain merits from the safety standpoint, most of these clutches must be reset manually; therefore, ready access must be provided.

Balls or rollers can be interposed between a smooth outer drum and a profiled inner drum to achieve various types of clutching action. Ball clutches are also made with a profiled outer drum, *Fig.* 13 and in this and similar forms they are found in many miniature drives, control knobs, servomechanisms, and business machines. Roller clutches are more suitable for heavier service and are frequently applied in strip stock feeds, dual drives, indexing devices and machines requiring "freewheeling." These will be discussed in detail later in this article.

Friction Clutches: The friction clutch has three basic elements; a set of opposing friction surfaces, means for transmitting torque to and from the friction surfaces, and a mechanism for forcing the friction surfaces into contact. Over the years a large number of designs have been devised for each element, so that the total number of possible construc-





Wheel running free. Clutch (C) and Pawl (P) out of engagement.

Clutch (C) beginning to engage, with ample time to complete full engagement.

Locking or "backing" pawl (P) beginning to engage, with 45 degrees to complete full engagement.

Shaft (S) and driving wheel (W) locked tightly together.

Fig. 10—In the rolling key power press clutch, the hub is grooved axially to receive a long key with a double-convex cross-section. Loaded by a torsion spring tending to turn it into engagement with one of the hub grooves, the key is restrained by a hook projection contacting a throwout latch pivoted on the machine frame. To engage the clutch, the throwout latch is swung aside, and the torsion spring carries the key into engagement as shown by the four-step diagram. A secondary key interlocked with the clutch key assures that the crankshaft will not ride ahead of the flywheel

—Courtesy, E. W. Bliss Co.

tions becomes staggering. Fortunately, experience has simplified the design problem to the point that a fairly straightforward selection can be made for a specific application.

Whenever a friction clutch is engaged to join two members having relative motion, there is a period of slip which may last several seconds. This slip is one of the chief merits of the friction clutch, for it cushions shock and prevents excessive torsional stresses on the entire power transmission system. On the other hand, slip is a limiting factor in friction clutch performance, for heat is generated in proportion to slip (speed difference), torque transmitted, and period of slip.

THERMAL CONSIDERATIONS: For a specific speed and inertia condition, and a constant clutch adjustment, heat generated in a friction clutch is proportional to the frequency of engagement. Since each friction surface has a limiting temperature beyond which its efficiency is first temporarily then permanently impaired, frictional heat must be dissipated at a rate sufficient to keep the temperature at a safe level. Excessive heat also may cause distortion and warping of the clutch members, producing hot spots and accelerating lining failure.

As a rule, and within practical limits, the most convenient safeguard against clutch overheating is to specify an oversize clutch. The larger the clutch, the greater will be the initial cost, but the lower will be the operating cost. The greater the mass to absorb the heat of engagement, the lesser will be the temperature rise. Also, the greater radiating surface will speed heat dissipation. In addition, a greater area of friction lining and a larger mean effective radius will permit considerably lower contact pressures thus reducing lining wear. While there may be special

reasons for holding clutch size to the minimum, such as space limitations or considerations of clutch weight or inertia, in general, thermal efficiency should not be sacrificed.

To illustrate the effect of torque load and frequency of engagement on clutch life, one authority[1] cites the following data from a series of friction clutch tests:

Torque Load	Frequency (starts/hr)	Satisfactory* Starts
Max. Rating	180	10
Max. Rating	1	500
½ Max. Rating	180	50,000

*Before slippage necessitated readjustment

Extensive studies have revealed that, up to the point of destruction, wear is an exponential function of the average rate of heat generation.

In designing for maximum capacity within a given space, the problem of overheating is met by two approaches: the use of constructions giving maximum heat dissipation and minimum warpage, and the use of friction materials that are affected by heat as little as possible. These friction materials must of course possess adequate mechanical strength as well as good thermal properties.

Design for heat dissipation involves the use of short, highly-conductive heat transfer paths, with friction surfaces exposed liberally for air-cooling. In this connection, it is interesting to note that in one successful aircraft brake design the friction material has been reduced to a single pair of small buttons pressing against opposite sides of a steel disk. Most of the disk is exposed, and as a result, it stays cool because of the excellent convective transfer to the surrounding air. For the same reason, despite the unusually small friction lining area and the high surface pressure, the friction buttons are not subject to the heat fading and excessive wear found when full-lined brakes are applied continuously. It is interesting to note that in tests this same brake failed when a second pair of buttons was added experimentally at a point diametrically opposite the first pair—heating then became cumulative.

Other means for improving heat dissipation include finned surfaces for increasing heat transfer areas and air turbulence, and roughened exterior surfaces for improving radiation. For example, a sand-cast surface has about five times the heat radiation capability of a comparable surface with a fine machined finish. Some clutches are designed to run "wet" (in oil) to secure liquid cooling, which is very successful provided the oil does not become hot enough to gum and carbonize.

When heat warpage is found to be a problem, the solution may become involved. A typical answer is

[1] References are tabulated at end of article.

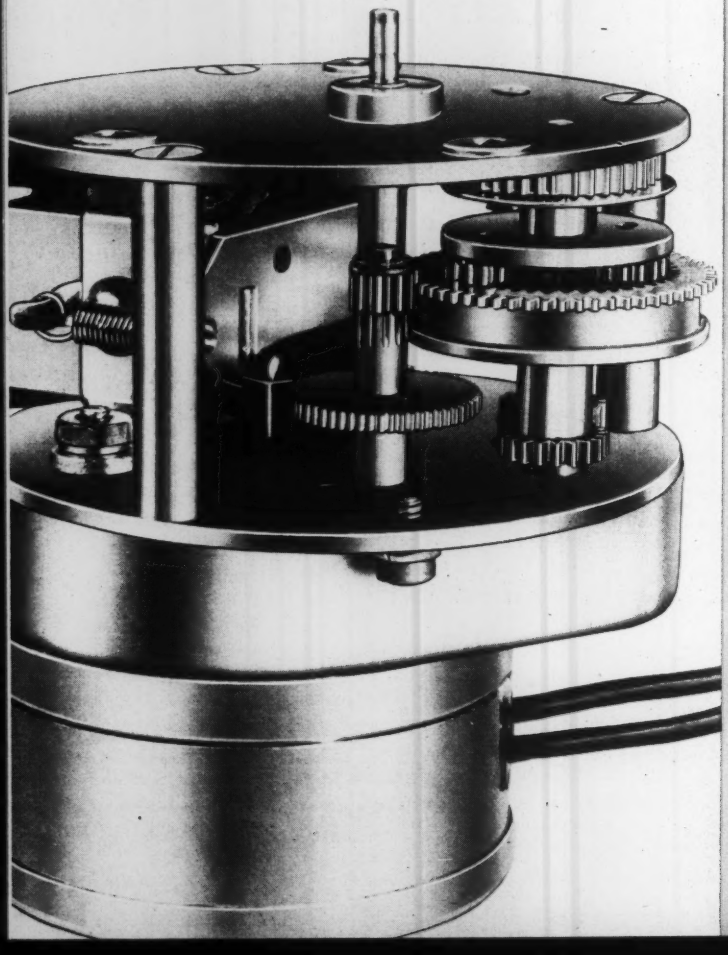
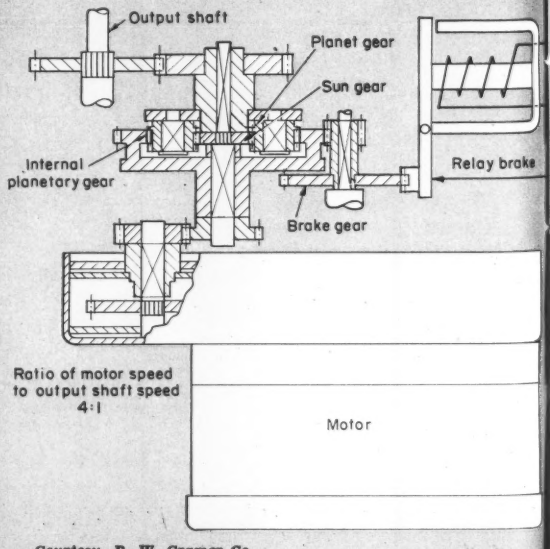
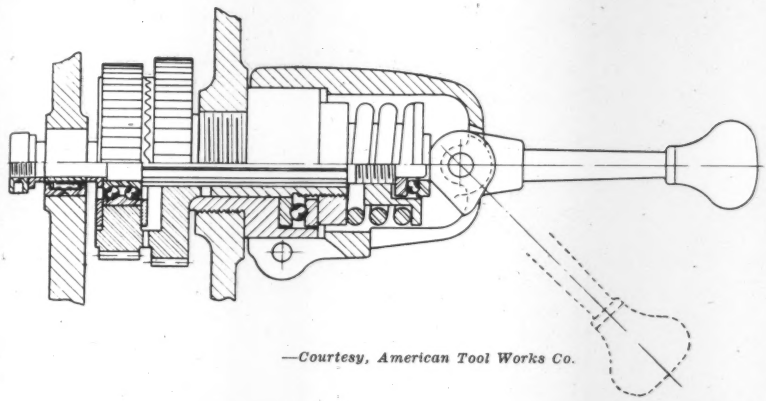


Fig. 11—Positive clutch action is effected in one industrial timer through solenoid actuated pawl-brake control of the ring gear in a continuously driven planetary gear transmission. Brake release discontinues power output from the planetary, permitting the timer to reset

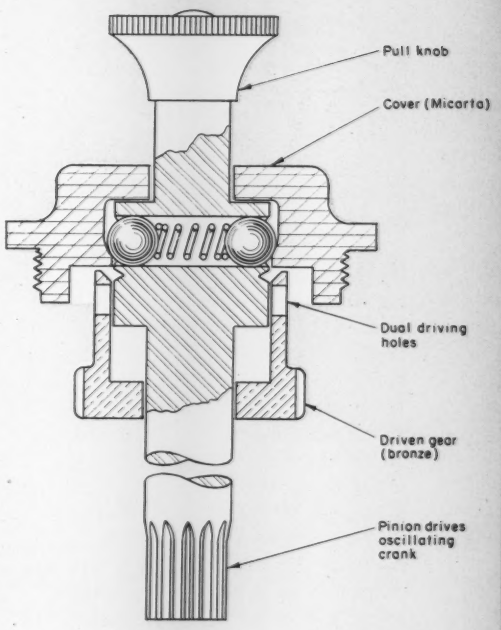


—Courtesy, R. W. Cramer Co.



—Courtesy, American Tool Works Co.

Fig. 12—Above—Overload safety is built into a positive clutch in a metalworking lathe to insure crossfeed within the capacity of the machine. If excessive resistance or a solid obstruction is encountered, clutch slippage produces an audible signal to warn the operator



—Courtesy, Westinghouse Electric Corp.

Fig. 13—Right—A ball and spring detent clutch protects the oscillating drive on electric desk fan. The clutch will slip without harm upon meeting a predetermined resistance. In the disengaged position shown, the balls engage the housing cover and provide frictional resistance for positioning the fan

to use expansion-relieving cuts or grooves in the member supporting the friction materials, but there is no pat answer. Actually warpage is usually less of a limiting factor in clutch design than the temperature of the friction surface. Studies of this phase of the problem have proved a fruitful line of attack in increasing clutch ratings.

FRICTION MATERIALS: Some decades ago, the principal friction materials available were leather, wood (maple, elm or lignum-vitae), cork, or felt operating against metal. While these organics are reasonably durable and give a satisfactory coefficient of friction, they are adversely affected by moisture and by comparatively small temperature rises. In most of these materials, bleeding of the natural resins and charring become noticeable at 175 F, with resultant loss of friction and rapid wear. The energy absorbtion capacity of wood, for instance, is given as 250 lb-ft per minute per square inch, as compared to 1000 to 2500 lb-ft permissible with standard asbestos materials and 10,000 lb-ft permissible with certain all-metal friction materials under good heat dissipating conditions[2].

Cork and felt possess the special property of high resiliency and have worked out very well in friction clutches for light drives, such as wire recorder tension controls and sewing machines. They were used successfully in a number of early automotive clutches, although most cars now use asbestos-base materials.

The metal-to-metal designs of the past employed standard bearing combinations, such as bronze on steel or cast iron on cast iron. Although suitable for somewhat higher temperatures than the natural nonmetallics, these metal combinations labored under the disadvantages of a low friction coefficient, a need for careful lubrication (excepting cast iron on cast iron), and a tendency toward sparking (except bronze). Galling presented a serious problem with bronze on steel. Accordingly, when any of the basic metal combinations are used, clutch size, weight, and inertia will necessarily be greater than for the nonmetallic facings or linings, and utility will be limited. As clutch friction materials, the basic metals are limited in general for low-speed, low-torque applications where the cost of special facings is not justified.

The modern asbestos-base and powder-metal friction materials were developed to overcome the various limitations of their predecessors. They permit a considerable reduction in clutch size for a given load and thus more than offset their added cost. Also they are far less affected by adverse environmental conditions, wear less rapidly, and many types are available for wet or dry operation. TABLE 3 presents a composite picture of clutch friction materials.

Woven Asbestos: Asbestos fiber is woven around brass, lead, copper, or zinc wire, impregnated with asphalts, rubber, drying oils, or other resins, and then baked and heavily compressed. The glazed surface is sometimes finished by grinding to shorten breaking-in time. This is the original asbestos friction material, and it remains in demand because of its flexibility and durability. Ordinarily it is fastened to a metal backing plate with rivets although special ce-

ments are also used. Cementing allows utilization of approximately 15 per cent more lining area which otherwise is wasted by the rivet method, permits wear almost through the full thickness of lining and prevents scoring of the opposing surface. Cementing and riveting may be used in combination in heavy-duty applications.

Molded Asbestos: Short asbestos fiber bonded with ingredients similar to those used for woven lining are employed for molded asbestos linings. Brass chips, iron oxide, emery, etc., may be added to increase friction for use with cast iron. Graphite or mica may be added to reduce friction for use with steel which is more susceptible to scoring and cutting. Another variation may be a wire mesh backing, adding flexibility and reinforcement. Because of its versatility, low cost, and comparatively high strength and hardness, molded lining is used extensively.

Molded Semimetallics: Developed within the last decade, this material consists of asbestos, copper powder, and a synthetic bonding resin. The lining is molded in thickness ranging from 1/64-in. to ⅛-in. directly onto a steel shoe or other backing. Because of the copper powder and the short heat travel path, this material is rated higher than plain molded lining. It is also more expensive, and therefore, is reserved for premium applications, such as bands in automatic transmissions.

Powder Metals: Powder-metal friction materials employ various combinations of powder iron, copper, lead, zinc, silicon, and tin, plus nonmetallic powders such as graphite, silicon carbide, silica, and alumina. The material wears slowly and accordingly permits use of thin sections to minimize cost and weight. It is brittle, however, usually requiring a steel, copper or cast iron backing plate to which it is bonded under pressure and heat. Subsequent grinding or lapping provides a typical final thickness of 0.007-inch facing.

Although expensive, as a result of the special processing required, sintered facings offer many important advantages in clutch performance. Outstanding among these are: constant frictional characteristic within a wide operating temperature range, excellent heat conductivity, high resistance to galling and scoring, and insensitivity to moisture, solvents, oils, etc.

Graphitized Carbon: Special mention is made of the carbon-graphite materials such as Graphitar, Purebon, etc. While these materials are too brittle and expensive for routine use, they are well worth considering for severe duty in small clutches and where much slippage is required. The thermal conductivity is higher than for cast iron, and the material will withstand very high pressures and speeds without galling or excessive wear. Rate of wear is indicated by the pressure-velocity product: $PV = K$, where P = pressure, psi, and V = velocity, fpm. The maximum value of K is 150,000 for lubricated, and 15,000 for nonlubricated surfaces. The material can be operated at a higher value of K on intermittent duty, satisfactory results having been recorded with a K value as high as 2,000,000. This value is equivalent to a 6-in. diameter clutch ring running at 4250 rpm under 300 psi loading.

A word of caution is in order concerning friction coefficients. In clutch design practice, the nominal coefficient of friction is usually taken as one-half to

Table 3—Friction Materials For Clutches

Contact Surfaces: Wearing	Contact Surfaces: Opposing†	Friction Coefficient*: Wet	Friction Coefficient*: Dry	Max. Temp. (F)	Max. Pressure (psi)	Relative Cost	Comment
Cast bronze	Cast iron or steel	0.05	...	300	80 to 120	Low	Subject to seizing
Cast iron	Cast iron	0.05	0.15 to 0.2	600	150 to 250	Very low	Good at low speeds
Cast iron	Steel	0.06	....	500	120 to 200	Very low	Fair at low speeds
Hard steel	Hard steel	0.05	....	500	100	Moderate	Subject to galling
Hard steel	Hard steel, chr. plated	0.03	....	500	200	High	Durable combination
Hard-drawn phos. bronze	Hard steel, chr. plated	0.03	....	500	150	High	Good wearing qualities
Powder metal§	Cast iron or steel	0.05 to 0.1	0.1 to 0.4	1000	150	High	Good wearing qualities
Powder metal§	Hard steel, chr. plated	0.05 to 0.1	0.1 to 0.3	1000	300	Very high	High energy absorption
Wood	Cast iron or steel	0.16	0.2 to 0.35	300	60 to 90	Lowest	Unsuitable at high speed
Leather	Cast iron or steel	0.12 to 0.15	0.3 to 0.5	200	10 to 40	Very low	Subject to glazing
Cork	Cast iron or steel	0.15 to 0.25	0.3 to 0.5	200	8 to 14	Very low	Cork insert type preferred
Felt	Cast iron or steel	0.18	0.22	280	5 to 10	Low	Resilient engagement
Vulcanized fiber or paper	Cast iron or steel	....	0.3 to 0.5	200	10 to 40	Very low	Low speeds, light duty
Woven asbestos§	Cast iron or steel	0.1 to 0.2	0.3 to 0.6	350 to 500	50 to 100	Low	Prolonged slip service rating given
Woven asbestos	Cast iron or steel	0.1 to 0.2	....	500	100 to 200	Low	This rating for short infrequent engagements
Woven asbestos	Hard steel, chr. plated	0.1	....	...	1200	Moderate	Used in Napier Sabre engine
Molded asbestos§	Cast iron or steel	0.08 to 0.12	0.2 to 0.5	500	50 to 150	Very low	Wide field of applications
Impregnated asbestos	Cast iron or steel	0.12	0.32	500 to 750	150	Moderate	For demanding applications
Carbon graphite	Steel	0.05 to 0.1	0.25	700 to 1000	300	High	For critical requirements
Molded phenolic plastic, macerated cloth base	Cast iron or steel	0.1 to 0.15	0.25	300	100	Low	For light special service

* Conservative values should be used to allow for possible glazing of clutch surfaces in service and for adverse operating conditions.

† Steel, where specified, should have a carbon content of approximately 0.70 per cent. Surfaces should be ground true and smooth.

§ For a specific material within this group the coefficient usually is maintained within plus or minus five per cent.

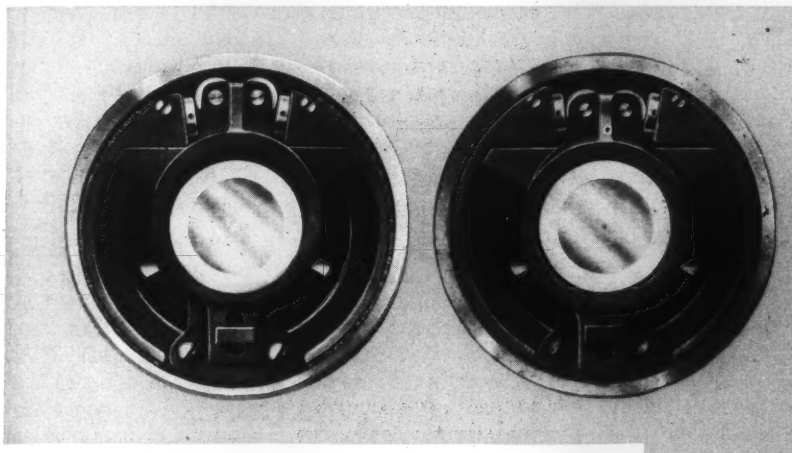


Fig. 14—A tapered groove in the shifter bushing of a friction rim clutch converts axial force into a radially inward force when it enters an eccentric yoke. Rollers in the yoke contact the inclined heads of adjustable pressure buttons, forcing the clutch shoes outward to engage the rim

—Courtesy, Brown Engineering Co.

three-quarters the value shown in TABLE 3. This provides a safety margin for wear, overloading, dirt, or other adverse conditions. Also, in calculations for contact pressure, the effective lining area should be considered rather than the gross, because of the spiral, radial, or criss-cross grooves often provided.

WET vs. DRY OPERATION: As noted in TABLE 3, many materials can be run either wet (oil) or dry. If run wet using a spray (preferred) or a shallow dip, the coefficient of friction is lowered, but it is usually possible to raise the working pressure to compensate partially for this. Grooves in the softer friction face are desirable, to improve the circulation and cooling effect of the oil, to prevent the formation of a hydrodynamic separating film, and to improve releasability.

In general, a wet clutch is smoother in action, wears less, and is much better suited for rapid cycling and heavy duty, mainly because of the cooling action of the oil. Because a wet clutch is totally enclosed, protection from abrasive substances is assured and there is little or no fire hazard in the presence of lint or inflammable vapors. In contrast, a dry clutch is simpler and more compact, idles with considerably less drag and heating, and is affected much less by extreme ambient temperatures. Again grooves often are provided in the softer friction face, principally to scavenge dirt or wear particles and to permit air circulation for cooling and rapid release.

In comparing wet and dry clutches, it is helpful to recall the troubles experienced with the wet clutch in yesteryear's automobiles: gearshifting was accompanied by much clashing of teeth on cold mornings because the viscous oil would not release. Then, too, as the oil thinned out after weeks of use, the clutch would develop a tendency to grab. A change of oil often resulted in clutch slippage.

It should be noted that while TABLE 3 lists most of the conventional friction materials and combinations, it does not begin to exhaust the possibilities. One unusual clutch arrangement used successfully to cushion the action of an aircraft engine starter[3] employs tempered phosphor bronze disks against steel. Because of the high pressure required, serious chattering was experienced initially as a result of trans-

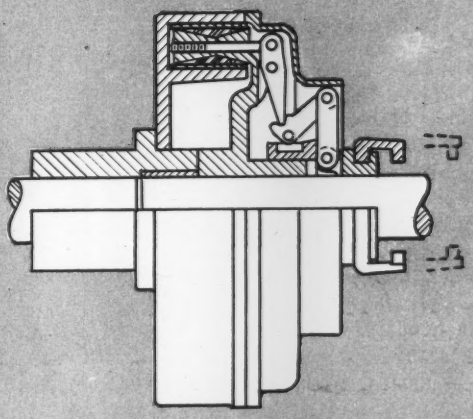
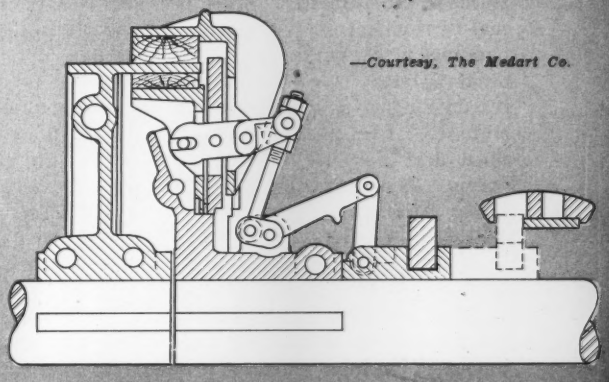


Fig. 15—Combination expansion-compression band clutch is energized by linkage-operated wedges. Mechanical advantage of the linkage minimizes operating force requirement

—Courtesy, Hanson Clutch & Machinery Co.

Fig. 16—Below—The Hill clutch coupling (Smith type) utilizes three pairs of asbestos friction shoes in the present-day version



—Courtesy, The Medart Co.

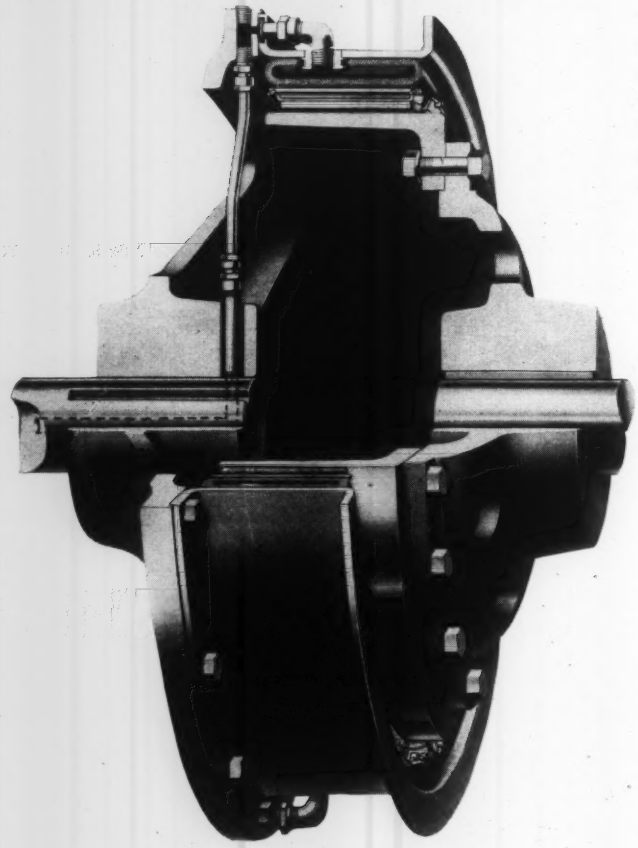
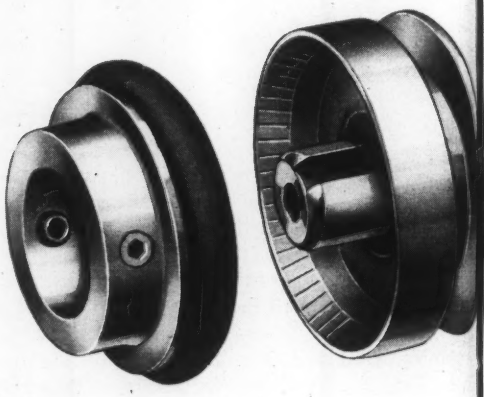


Fig. 17—Left—In the Airflex constricting shoe clutch, air pressure to inflate the gland is supplied through a ball-bearing rotary shaft seal, not shown. Resilience of the gland cushions vibration, makes slight shaft misalignment tolerable, and obviates wear adjustment

—Courtesy, Fawick Airflex Co. Inc.

Fig. 18—Below—Friction lining in a miniature cone clutch is a standard O-ring which contacts a knurled cone surface, giving quick starting and slip-free driving

—Courtesy, General Control Co.



fer of bronze to the steel disks, even when the bronze was tin plated. An attempt was made to overcome the difficulty with a large number of oil reservoir holes, but this was only partially successful. Chromium plating the steel disks was tried next and found satisfactory, but the cost was considered excessive. The final solution was to add a fine abrasive material to the oil to lap off the bronze as fast as transferred.

TYPICAL FRICTION CLUTCHES: Friction clutches usually fall into one of two principal classifications: rim clutches, wherein the contact pressure is applied normal to the shaft axis against a rim or drum as in expanding block, wrapping band, or roller types; and axial clutches, wherein the contact pressure is applied by shift movement along the shaft, as in cone or disk clutches. Rim clutches appear to have been developed first and are still used effectively in various forms. Usually they are simple, inexpensive, and fairly trouble-free, but most types are affected adversely by centrifugal force and consequently are limited to comparatively low-speed operation, particularly in large sizes.

The construction of one modern expanding shoe clutch is shown in *Fig.* 14. In the expanding clutch, pull-back springs must be provided to overcome the effects of centrifugal force and to permit rub-free idling. As a result, engagment force requirements can become comparatively high. The clutch in *Fig.* 14 minimizes operating force through roller actuation in lieu of the rocking or sliding wedge used in some designs. Self-energization is sometimes used to minimize control forces, but the effect is directional and there may be a tendency toward grabbing and chatter, particularly when new linings are installed.

Because the mean friction radius of the expanding clutch is nearly equal to its outside diameter, it has a rather high potential torque capacity for its size. The full potential is difficult to attain with the usual long shoe construction, because of the tendency toward nonuniform pressure and wear over the length of the shoe. Nevertheless, the shoe clutch is rated among the more powerful and can be used to transmit comparatively heavy shock loads. Heat dissipation is very good as a result of the exposed outer drum. All-in-all, the expanding shoe clutch is a relatively low-cost and effective unit for moderate requirements in speed, duty, and horsepower rating.

The converse of the expanding-shoe clutch is the contracting ring clutch. Despite its simplicity and ease of repair, it suffers by comparison with the former. Cooling is impaired by the insulating effect of the lining. Much of the mechanism must be located in an exposed, dangerous position on the clutch periphery; and centrifugal force tends to weaken, rather than strengthen the grip of the clutch. Contracting ring or band brakes, on the other hand, are commonly employed and are often used with planetary mechanisms to give clutch action. For example, as in the famous Model T Ford, many modern automotive transmissions utilize this principle to effect clutch action in changing speed ratios.

A combined expansion-contraction clutch, *Fig.* 15, gives unusually high capacity for a given length and diameter of drum and is well suited to heavy line-shaft service where engagements are not overly frequent.

Another type of rim clutch that has proved its worth through the years is the Hill clutch, *Fig.* 16, based on the fundamental principle of a double-shoe clamp on the inside and outside of a driving rim. The effect of centrifugal force on the shoes is nullified in the Hill construction, so that speed is limited only by the balancing problem. Also, there is no self-energization. The clutch is powerful, easy to maintain, and dissipates heat well. An unusual feature of this design is the loose-jointed flexible coupling action, which avoids the need for accurate alignment characteristic of most other clutches. The principal drawback is its complexity.

Levers are avoided in one well-known rim-type clutch, *Fig.* 17, which is actuated by an inflating tube. This clutch is available with either expanding or constricting ring shoes. Of these two, the expanding ring style is more powerful and compact and is well adapted to slipping service. It is, however, limited to relatively low speeds where heavy springs are not required to overcome centrifugal forces when disengaging. The constricting ring designs are under no such handicap because the air pressure acts against centrifugal force; consequently maximum speeds are adequate for most high-speed machinery, as indicated in TABLE 1. In either model, the flexible tube serves also as a limited flexible coupling and dampens torsional shocks. This clutch has accordingly proved particularly successful on diesel engine drives.

In axial clutches movement between the contacting members is parallel to the shaft. One result is that these clutches are free from the effects of centrifugal force, except as it might affect the actuating

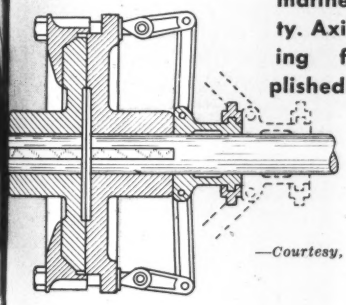


Fig. 19—Worrall all-metal clutch performs low-speed marine and line-shaft duty. Axial clamping of driving flange is accomplished through lever cams

—Courtesy, Newton Clutch Co.

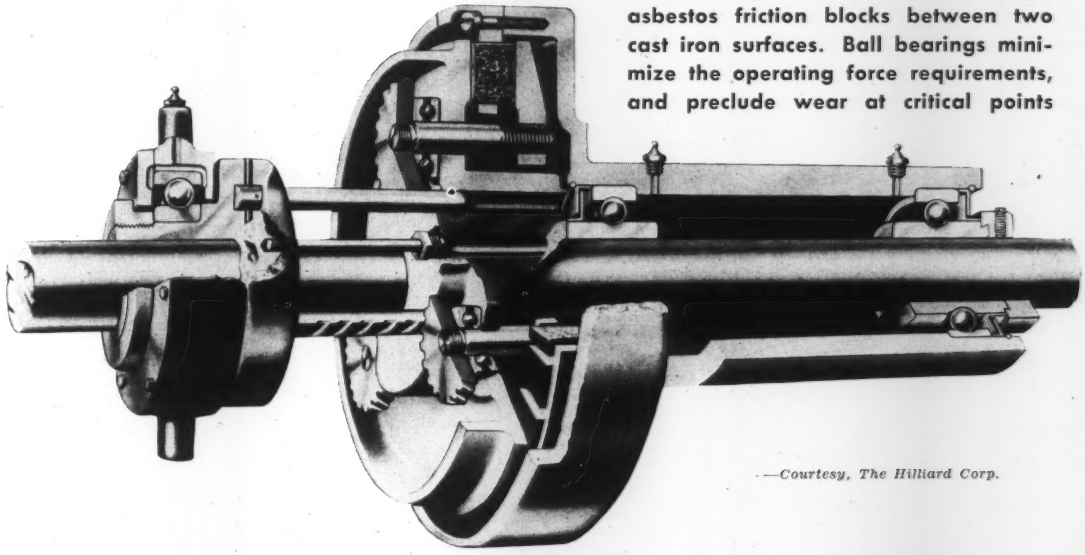


Fig. 20—Smooth, gradual engagement is achieved in this axial clutch through the use of gear-driven screws to clamp asbestos friction blocks between two cast iron surfaces. Ball bearings minimize the operating force requirements, and preclude wear at critical points

—Courtesy, The Hilliard Corp.

levers at extremely high speeds. There are several other advantages of the axial clutch: large total friction surfaces are possible for a given size and weight, the effective heat dissipating surfaces are favorable and pressure distribution is more uniform over the friction lining area.

One of the earliest axial-type clutches that was developed is the familiar cone clutch. Simple in construction and comparatively powerful for a given outside diameter and axial energizing force, the cone clutch was used on a number of early automobiles. In this particular application it was found far from satisfactory, because high inertia resulted in gear clashing. When the cone angle was reduced to permit use of smaller diameters, the clutching action became objectionably severe.

A period of development followed during which various devices were tried to eliminate grabbing and smooth out and prolong the period of engagement. The best results were achieved with multiple springs spotted under the cone lining to produce a series of bulges which gave a gentle preliminary contact. These springs eased engagement fairly well, but they wore the lining unevenly and added considerably to the inertia, defeating the whole purpose of the idea.

The modern tendency is to limit cone clutches to fairly low peripheral velocities; for instance, machine tool feeds, drill press tapping attachments, synchronizing clutches in "synchromesh" transmissions, and other low horsepower applications, *Fig.* 18. Under such conditions the characteristic sudden pick-up of load is not objectionable, and the designer can take advantage of the clutch's simplicity and high capacity. Cone clutches are also used effectively for overload release units which will be discussed later in this article.

In contrast to the cone clutch, most other types of axial clutches have flat friction surfaces or disks. The Worrall, *Fig.* 19, a very early type still being made, is based on the principle of the solid flange coupling. It uses two lubricated cast iron flanges clamped together at four points of the periphery by a quick-release mechanism. This design affords one rubbing surface.

Most of the present day single-disk clutch designs provide two pairs of rubbing surfaces, *Fig.* 20, for maximum torque capacity and wear life within a given diameter. In this unusual design which, incidentally, is an old timer in principle, the friction material consists of molded asbestos blocks carried in a cut-out driving plate—a construction that has been employed effectively on heavy-duty drives by a number of manufacturers. A unique feature of this clutch is the rack and gear actuation which gives "micrometer" control over the load and permits smooth engagement with slow or rapid pick-up as desired. Considerable wear take-up is afforded, minimizing adjustment. For these reasons the primary use of this clutch is in connection with heavy inertia loads; for example, tumbling barrels, heavy paper machinery such as corrugators and slotters, and amusement park machines.

Instead of the solid asbestos block construction,

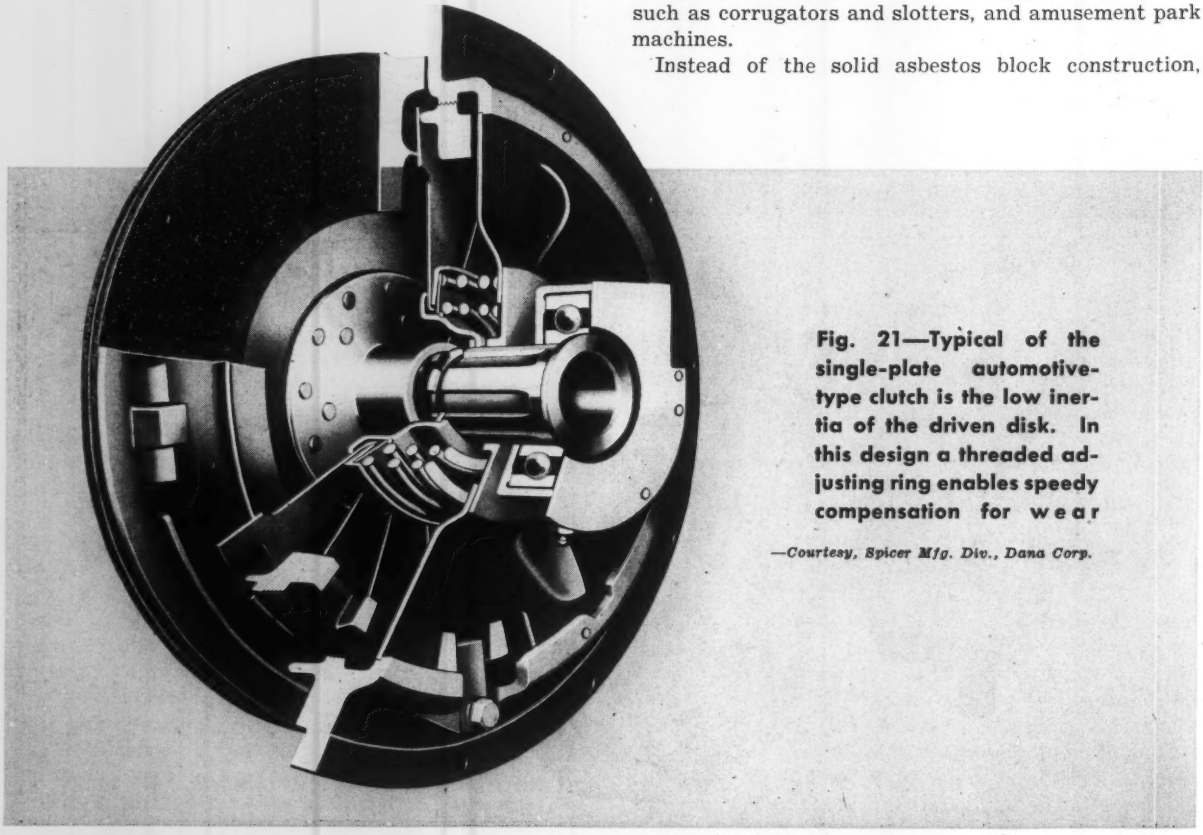


Fig. 21—Typical of the single-plate automotive-type clutch is the low inertia of the driven disk. In this design a threaded adjusting ring enables speedy compensation for wear

—Courtesy, Spicer Mfg. Div., Dana Corp.

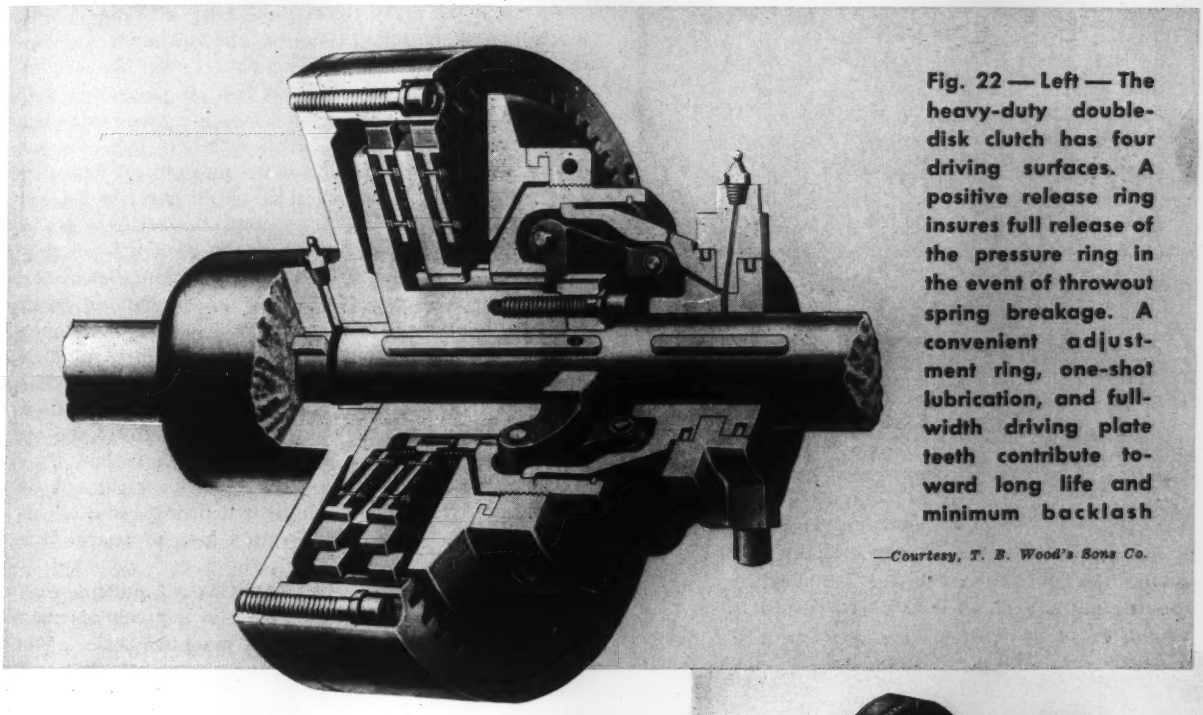


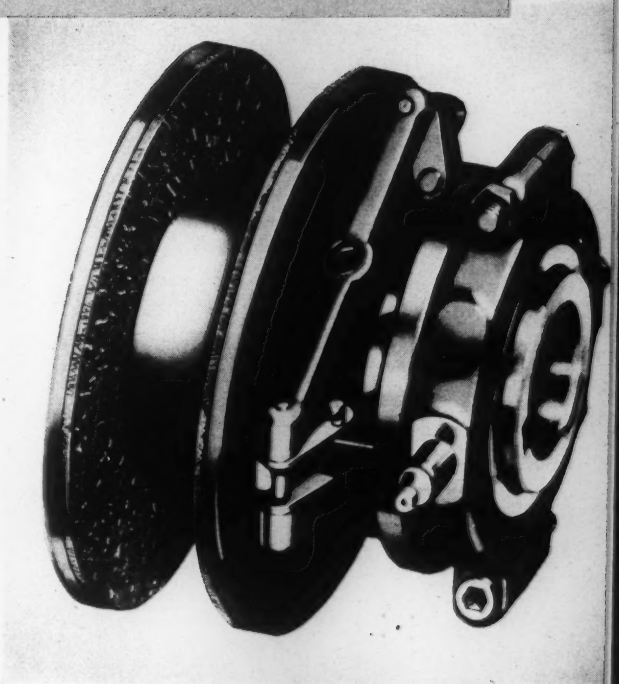
Fig. 22 — Left — The heavy-duty double-disk clutch has four driving surfaces. A positive release ring insures full release of the pressure ring in the event of throwout spring breakage. A convenient adjustment ring, one-shot lubrication, and full-width driving plate teeth contribute toward long life and minimum backlash

—Courtesy, T. B. Wood's Sons Co.

use is often made of less costly molded or die-cut friction linings riveted or cemented to both sides of a steel driving plate. A familiar example of this is the highly-developed automotive clutch, *Fig.* 21. In heavy industrial clutches, the backing plates usually are split into two segments, to make replacement a matter of minutes, rather than hours. To offset the effect of centrifugal force, the halves may be overlapped and screwed together, depending on the speed and method of driving. As in *Fig.* 22, the steel backing plates may have external gear teeth which engage mating internal teeth in the driving member. This construction permits axial floating for wear take-up and free disengagement, but unless adequate tooth width is provided, the teeth may become worn prematurely under severe shock conditions, resulting in noisy operation and objectionable backlash. In driving heavy vibrating loads, particularly where backlash and the resultant clatter cannot be tolerated, the half-circle friction elements are bolted to the face of the driving member instead of to a separate backing plate.

As an alternative to the metal-supported friction lining, a solid ring of molded material often is used in the smaller clutch sizes. The principal difference is that the overall thickness of the friction plate is made several times greater than that of a comparable built-up type to provide adequate tooth strength.

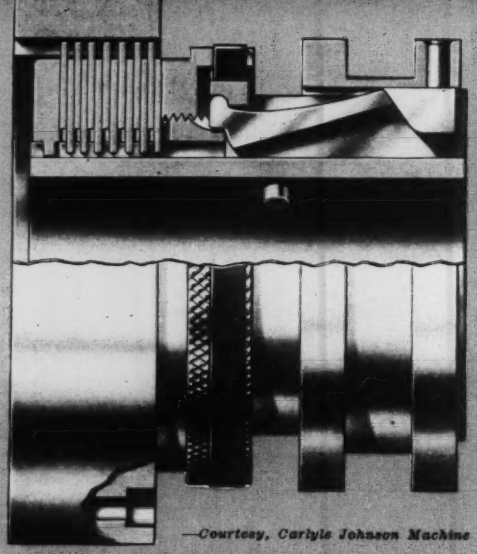
Friction elements often are arranged to clamp-engage the hub faces of a sprocket or sheave, *Fig.* 23. The resulting clutch is simple, compact and inexpensive. It should, however, be idled for short infrequent periods only, to avoid localized wear of the plain bearing surfaces. Accordingly, idling limitations in this clutch are governed largely by bearing proportions.



—Courtesy, Rockford Clutch Div., Borg-Warner Corp.

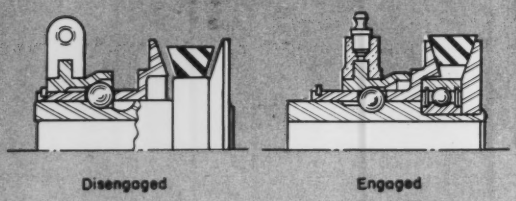
Fig. 23—Double-faced axial clutch arranged to carry a floating sprocket or V-belt pulley. Friction engagement is with the hub ends

In disk or plate clutches, although the mean friction radius is somewhat less than that in a rim type clutch or a cone clutch of equivalent outside diameter, this difference is more than offset by the fact that a number of friction elements may be stacked along the clutch axis to multiply torque capacity.



—Courtesy, Carlyle Johnson Machine Co.

Fig. 24—Above—Space requirement is small in the multiple-disk machine tool clutch. The particular design shown is for nonlocking operation and is especially suitable for brief periods of engagements. This clutch is made also in a standard self-locking style



—Courtesy, V-Belt Clutch Co.

Fig. 25—Above—The V-belt clutch drives frictionally on the sides of the V-belt. A ball bearing supports the belt while idling and minimizes wear; four balls lock the movable flange and key it to the mounting sleeve

As many as sixty disks have been stacked in one multiple-disk clutch. Usually, the optimum number of disks is found to be somewhat fewer because of two limiting factors. The first is heat generation and dissipation. Multiple-disk clutches must be restricted to one-half or one-third as many starts per hour as a single-disk clutch of the same mechanical capacity and material. The more disks, the greater is the restriction necessary. The second limitation results from the slight axial movement of each disk during clutching. At the start of engagement the disks offer only slight resistance to sliding on the driving teeth or lugs, but as the clutch takes hold, the resistance to sliding increases until each disk consumes as much as 10 per cent of the energizing force reaching it. The force on the end disk of a 10-disk stack would then be, approximately, only 35 per cent of the force on the first disk. These forces eventually equalize after engagement through creepage and vibration, but at the time of engagement there is a definite loss of capacity. This loss is considerably less, of course, for clutches running in oil.

A typical example of the lubricated multiple-disk clutch is shown in *Fig.* 24. This is a precision unit, made for demanding service in machine tools. The friction disks are metallic, and often are grooved axially to wipe off excess oil and speed contact when engaged. Hard steel (Rockwell C hardness of 45 to 50) on hard steel is used. For higher ratings, phosphor bronze or sintered bronze wearing disks are used against steel. This clutch is characterized by its high torque and thermal capacity, high maximum speed, low inertia and long life. In this regard, there are records of successful heavy-duty operation in automatic machines at cycling frequencies of several hundred engagements per minute (wet operation).

One of the principal design problems in connection with the multiple-disk clutch, particularly when operated wet, is a tendency for the disks to adhere after release. The result is serious dragging, wear, and possible overheating. Various separating devices have been developed, including coil springs and alternate flat and warped disks. A successful arrangement is

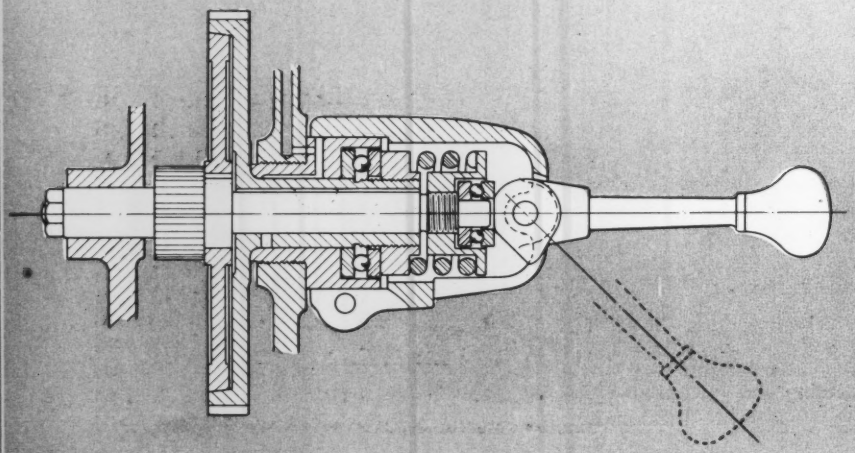


Fig. 26—Lubricated cast iron frictional surfaces of a lathe carriage cone clutch prevent inadvertent damage to the traverse feed. Predetermined torque capacity is maintained by a thrust spring, thus to permit driving the carriage harmlessly and effectively to a micrometer stop

—Courtesy, American Tool Works Co.

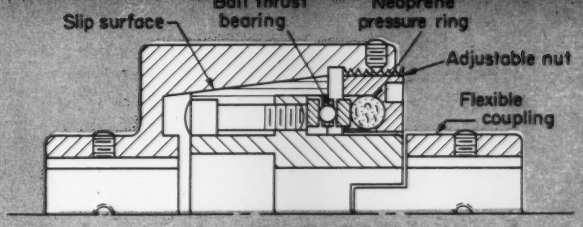
found in the clutch of *Fig.* 24, which uses wave-type separator springs between each pair of disks. Operation is satisfactory in the vertical as well as in the horizontal position.

Somewhat analogous to the tight and loose pulley arrangements devised years ago to provide friction clutch action in flat-belt machine drives, the so-called V-belt clutch, *Fig.* 25, performs axial clutch service capably in low-horsepower single-belt drives. In small sizes, this design works well, with very little wear on the belt even when operated over a hundred times per minute. The ease with which the "friction lining" may be replaced is a creditable feature inasmuch as disassembly is unnecessary. Representative applications of the V-belt clutch include small-size gasoline engine power take-offs, bilge pumps. conveyors, and automatic lathes.

Frictional Overload-Release Clutches: Particularly in high-speed machinery, the suitability of a positive overload-release clutch is seriously limited by the fact that it must be adjusted to sustain the starting torque as well as the relatively lower normal running torque, unless special starting facilities are provided. This limitation is nonexistent in friction slip devices, which also promote easy starting. Another apparent advantage is that the resulting cushioned torque transmission is conducive to long life of all parts in a drive system.

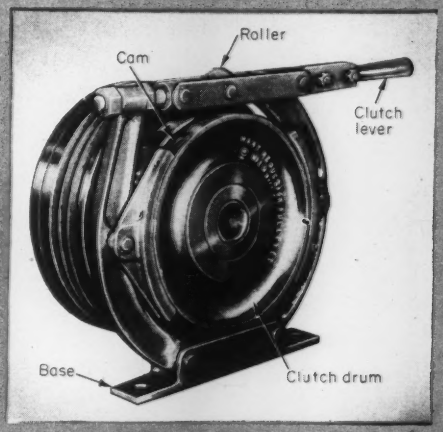
If the overload slip clutch is compared with a conventional on-off clutch, two major differences are discerned; one is the absence of an external control mechanism, except where purposeful disengagement is also desired, *Fig.* 26; the second is the provision of long-travel pressure springs against the friction lining to minimize the wear effect and permit sensitive adjustment. Steel helical or Belleville springs are customary, although rubber can be used if adequately removed from the zone of heat generation, *Fig.* 27.

Should slipping be allowed to continue unchecked



—Courtesy, Flaton Machine Works

Fig. 27—Automatic safety slip coupling with friction cone of cross-laminated, phenolic-bonded cotton duck derives torque capacity through compression of a neoprene ring. A ball thrust bearing prevents abrasion of the ring during slippage

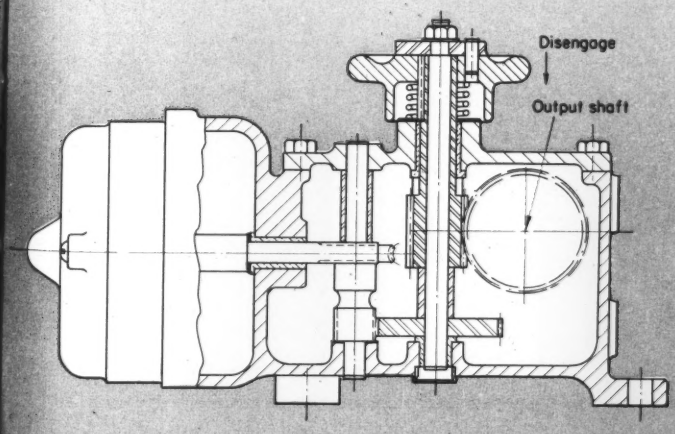


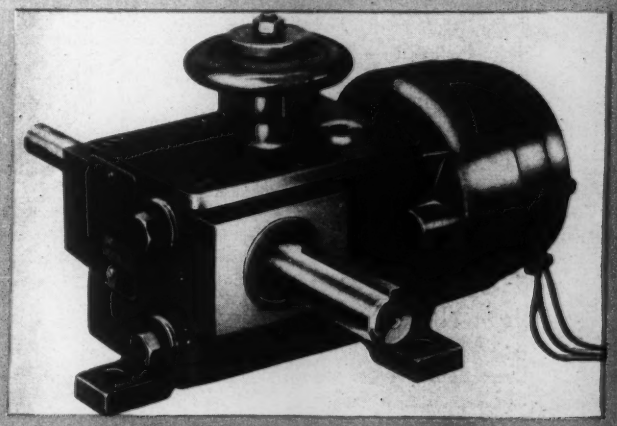
—Courtesy, Hart Reduction Pulley Co.

Fig. 28—Above—Shoe-type brake combined with a planetary speed reducer provides clutching action plus overload release. When overload causes slippage, an eccentric cam groove in the face of the drum lifts a throwout roller, opening a toggle lock and automatically disengaging the drive

Fig. 29—Below—Small high-ratio gearmotor has simple positive clutch control built into a positioning handwheel. The wheel is pushed inward to disengage the final worm reduction stage, permitting manual adjustment or rotation of the load

—Courtesy, Janette Electric Mfg. Co.





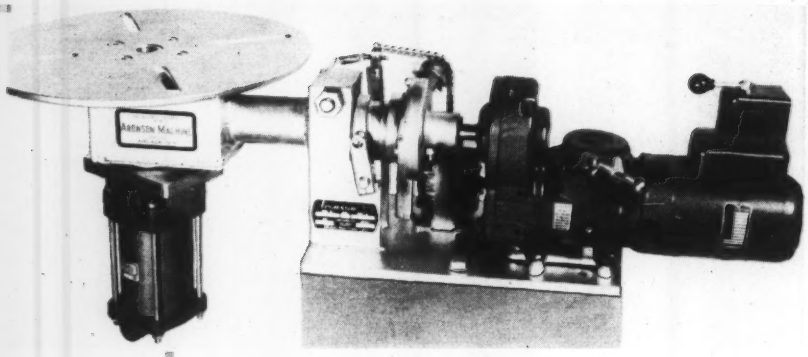
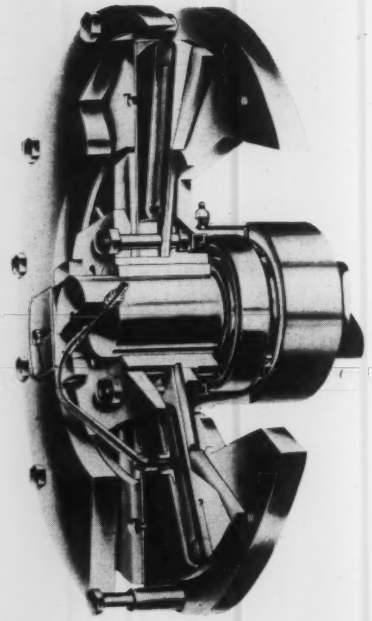


Fig. 30—Right—In an automatic welding positioner, a chain-operated friction clutch provides instant start and stop through solenoid control

—Courtesy, Aronson Machine Co.

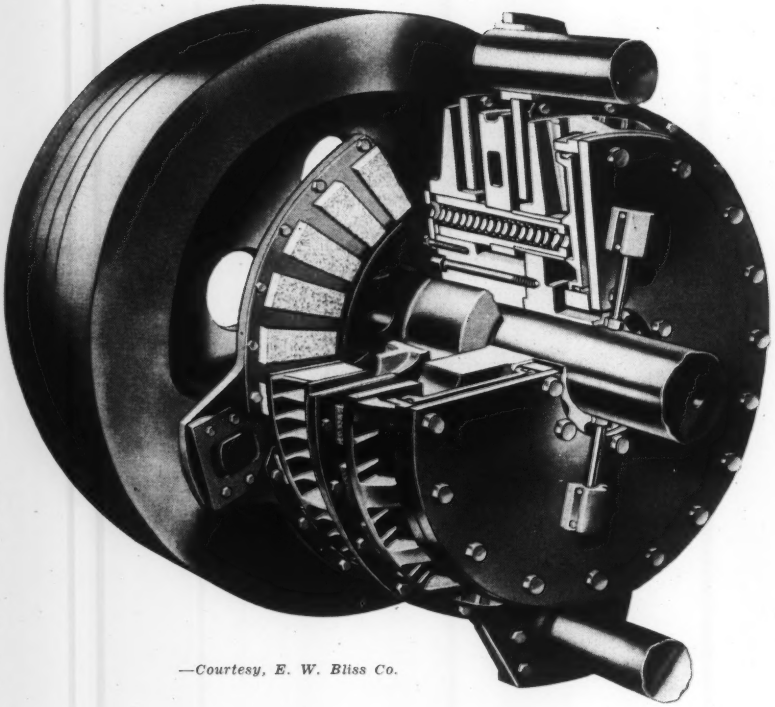


—Courtesy, Cardwell Mfg. Co. Inc.

Fig. 31—Above—Double friction elements are shifted axially by a circular air tube in the Flex-Disc clutch. Compact construction results in low axial space requirement

the lining will wear unnecessarily or may be destroyed through excessive heating. It is, therefore, customary to provide some means to indicate slippage, such as a small spring clapper or similar device for producing an audible signal. Alternatively, automatic shut-off can be secured by belting a standard motor plugging switch to the driven side of the clutch and wiring it into the motor control circuit to stop the motor in the event of slippage.

Another slip-responsive shut-off arrangement, *Fig.* 28, has an integral cam to effect disengagement. In this unit, which is also a planetary speed reducer, clutch action is produced through the engagement of a friction brake (or stationary clutch) with the ring gear of the unit. The clutch, or brake, is reset by



—Courtesy, E. W. Bliss Co.

Fig. 32 — Right — Combination disk clutch and brake for heavy-duty power press service is controlled by a single-acting annular air cylinder. Spaces between friction lining blocks and slots in the mating plate provide centrifugal fan action to assure rapid heat dissipation

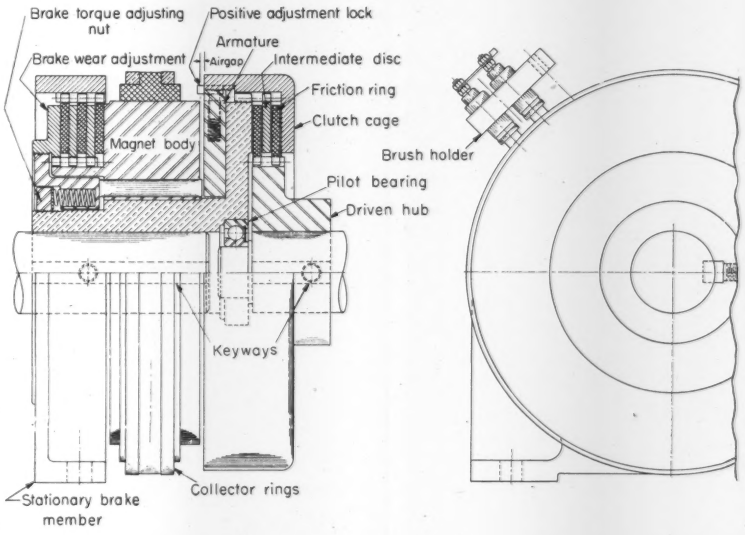


Fig. 33 — Right — In the magnetically controlled combination clutch and brake, mechanical interconnection assures automatic brake release when the clutch is energized

—Courtesy, Stearns Magnetic Mfg. Co.

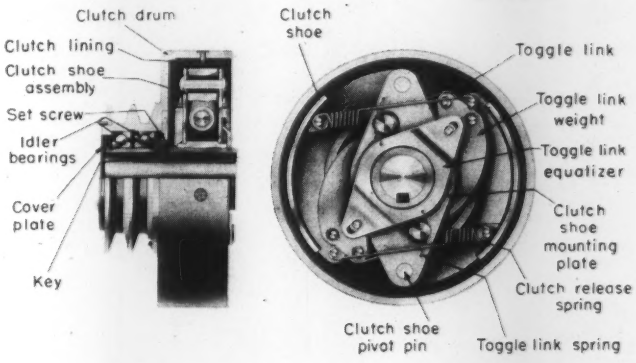


Fig. 34—Right — Equalizing arrangement in toggle linkage assures simultaneous operation of shoes in a drum-lined centrifugal clutch. Disengage speed is 300 rpm less than "lock-in" speed

—Courtesy, The Salsbury Corp.

means of a manual control lever. This type assembly is made by several companies. It is self-contained, fairly inexpensive, and reliable; it does, however, prevent using the clutch to ease starting loads or running shocks.

Friction overload-release clutches often are operated in continuous slip to provide constant windup torque. However, in order to prevent overheating, it is necessary to limit the transmitted torque to a conservative percentage of the torque permitted in straight overload release service. This percentage depends upon the clutch speed, size and construction, ambient temperature, and type of duty. Ordinarily, it will fall somewhere between 10 and 50 per cent.

Slip-service clutches are often provided with tension-sensing control to regulate the contact pressure. For example, they may be servoactuated by a dancer roll arrangement to maintain constant reeling tension by compensating for the torque variable caused by stock build-up on a reel.

Operating Mechanisms and Controls: Aside from the fundamental wearing surfaces, other clutch components are likewise subject to wear and may cause trouble. Accordingly, the designer or purchaser of a clutch should consider overall design details carefully. For example, the shaft bearing is an important item, whether it be a pilot bearing, as in *Fig.* 22, or a pulley support bearing in the sleeve clutch construction, *Fig.* 20.

When a clutch operates at a comparatively low speed, say below 250 rpm, a plain cast iron sleeve bearing is satisfactory, provided belt or chain loads are low and idling periods are short. With the same provisions, bronze bushings are considered suitable up to 750 rpm, depending on shaft size. Antifriction bearings, *Fig.* 20, are advisable for all higher speeds and for conditions of heavy loading or prolonged idling. In addition to offering long life and high efficiency, such bearings minimize lubrication and service requirements. For these reasons, unless it is known definitely in advance that clutch operating con-

Fig. 35—Right—Internal segmented shoes carried on a synthetic rubber gland are self-expanded hydraulically in the centrifugal mercury clutch. Friction shoe wear is distributed evenly because of inherently uniform engagement pressure

—Courtesy, Automatic Steel Products Inc., Mercury Clutch Div.

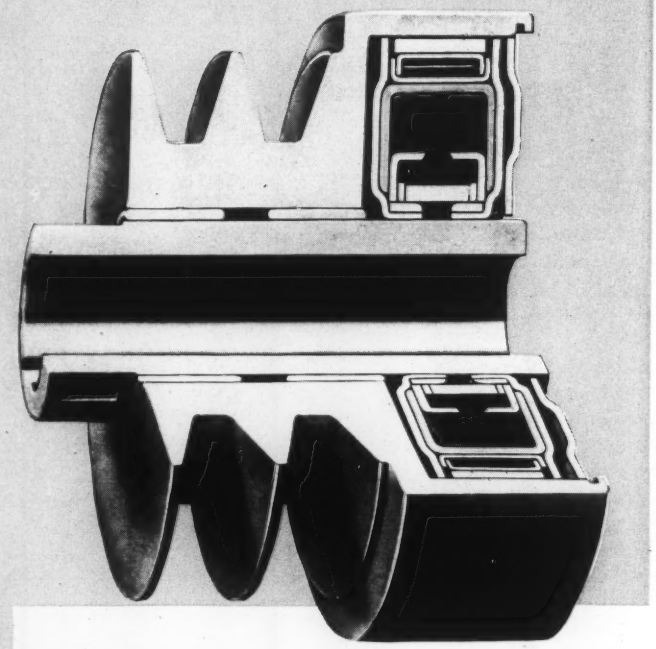
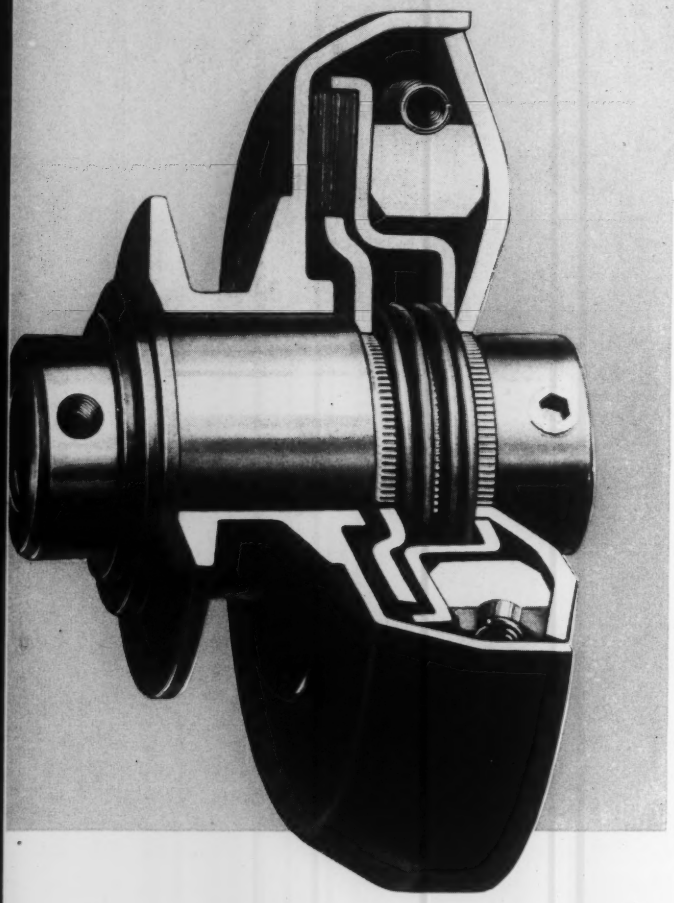


Fig. 36—Below—Friction inserts are pressurized through the conversion of centrifugal force to thrust by tapered ring segments in a combination clutch and V-belt pulley. Tension of the segment retaining spring determines engagement speed and releases the clutch at idling speed

—Courtesy, Automatic Steel Products Inc., Mercury Clutch Div.



ditions will never be severe, specification of antifriction bearings may prove worthwhile, despite the higher initial cost.

There is, it must be admitted, another school of thought on this subject: some users maintain that the gradual, predictable wear of a sleeve bearing is preferable to the possible sudden failure of an antifriction bearing. On the other hand, there is such a possibility as sleeve bearing seizure.

The internal clutch throw-out mechanism is exceptionally vital to satisfactory clutch performance. It should provide a satisfactory mechanical advantage at maximum mechanical efficiency to minimize operator effort. Except in special cases, the mechanism should be self-locking on and off, to avoid continuous loading and wear of the throw-out bearing. A certain amount of resiliency is essential in the parts: first, to achieve self-locking; and second, to provide take-up for wear and to minimize adjustment frequency. (Wear on a single disk automotive clutch will average from 0.001 to 0.004-in. per thousand engagements.) To provide maximum take-up, coil or Belleville springs may be used. The mechanism should be protected from dirt and well lubricated.

Many of the older clutches required adjustment at several points around the circumference. The modern tendency is to provide one central adjustment ring, *Fig.* 21, fitted with a fine thread to permit proper adjustment. In some clutches, centrifugal force tends either to lift away the levers and promote slippage at high speed, or else to tighten the grip and interfere with disengagement—balanced construction is best. When the actuating pressure is released, springs or other means should be provided for positively separating the clutching surfaces, particularly in the case of a disk clutch operating with its axis vertical.

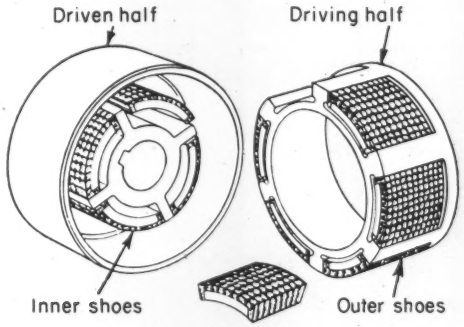
If a plain collar thrust bearing is used, the outer ring should be female, *Fig.* 19, unless seals are provided to retain the lubricant, *Fig.* 22. Male shifter shoes running in a groove are satisfactory for small clutches if made of self-lubricating materials or if operated in oil, per machine tool clutch practice. For high speeds or frequent operation, however, an antifriction throw-out bearing, *Fig.* 20, is preferable. In any event, pressure on the clutch thrust collar should be released after engagement, to prevent rapid wear.

A survey of clutch mechanisms reveals that innumerable schemes for obtaining mechanical advantage have been used. Some have met the requirements very well, others less so. One of the oldest arrangements is the over-center or toggle linkage, *Figs.* 15, 16, 19, and 23. Simple leverage, with spring actuation, is typical in automotive clutches, *Fig.* 21. Cams are employed frequently in conjunction with finger levers having pivot axes either tangential, *Fig.* 24, or radial. Cams contacted by roller levers minimize force requirements in larger sizes, *Fig.* 22. The wedge principle is also used, *Fig.* 15, as is the screw, *Fig.* 20.

Operating lever design is determined largely by the size and type of the clutch. For small clutches a direct lever or other simple form of shifter, *Fig.* 29, normally suffices. A direct slotted-hole connection can be made to the throw-out ring trunnions, *Fig.* 3, or short links can be used. The lever should be pivoted so that its weight does not tend to engage the clutch, and it should be located for convenient, safe manipulation. An operator should be able to stand where he has a clear view of the machine. A modern lathe exemplifies good manual clutch lever layout.

Where remote control is desired, solenoids can be used effectively to operate small clutches, *Figs.* 6, 11 and 30. As the size of the clutch increases, solenoids become less practical because of the corresponding increase in operating forces. Single revolution clutches, operating as they do on a trip-lever principle, are a notable exception.

The larger clutch sizes ordinarily require a compound leverage or gearing with handwheel control. Handwheel operation has the advantage of facilitating steady, smooth engagement. Where rapid release is required for safety reasons, faster than handwheel action is needed.



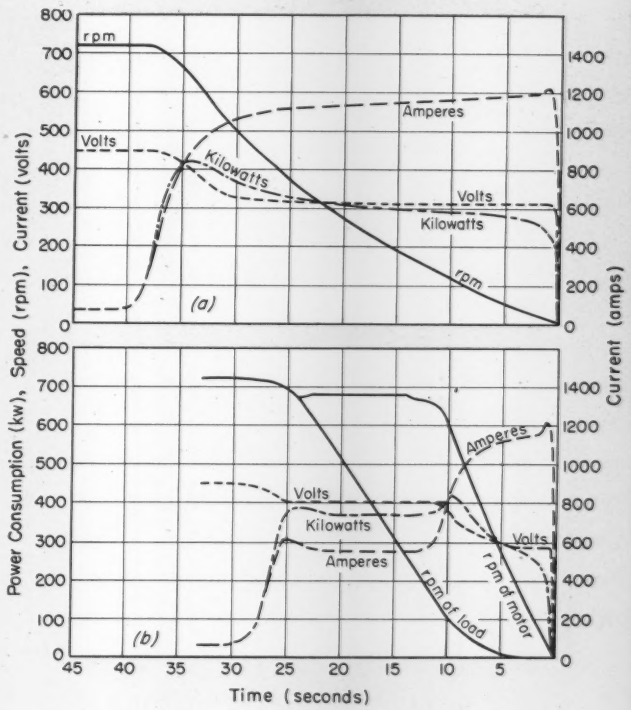
—Courtesy, Centric Clutch Co.

Fig. 37—The Rawson type centrifugal clutch utilizes two sets of shoes; an outer set carried on the driver, and an inner set on the driven member. When the driven half comes up to speed, engagement of the inner set of shoes increases the torque capacity 40 per cent

The control problem of large clutches could be handled through linkages operated by air cylinders or electric motors; however, a more logical plan is to dispense with complex mechanical lever actuation altogether and build air tubes, *Fig.* 31, air cylinders, or magnets into the clutch. This not only simplifies the clutch, but also improves performance. The direct air operated clutch, *Fig.* 32, occupies considerably less shaft space than a linkage operated clutch of equal capacity; it is self-adjusting for wear; and action is preset with metering valves as desired, for slow or extremely rapid torque build-up (typically to less than 0.1-second). Many power press manufacturers have adopted the direct air actuated clutch in medium and heavy presses because it offers fast action, long life (often several million starts between friction lining replacements), dependability and minimum down-time, plus the ability to be inched or emergency-stopped at any point in the press stroke.

Fig. 38—Power economy possibilities are indicated in these typical starting curves for a motor and high-inertia load. Chart *a* is for direct drive; *b* is same drive through a centrifugal clutch

—Courtesy, J. P. Madden



The clutch fails safe by stopping automatically should the air supply be interrupted.

Compressed air is, of course, only one possible power source for pistons. Vacuum operation, while limited as to force available in a given size envelope, has been successful in automotive clutch operation. Transmissions made especially for marine service by Twin Disc and Western Gear Works utilize the lubricating-oil pressure for clutch operation.

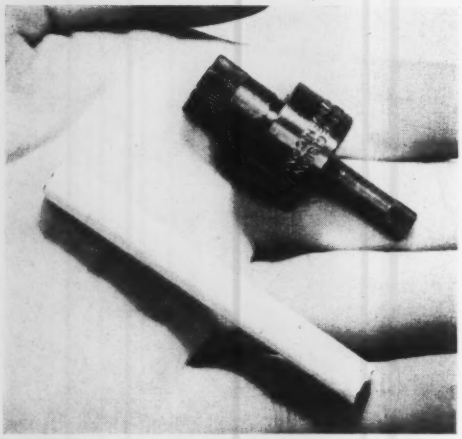
The rotating-magnet friction clutch, *Fig.* 33, is powered by magnets rather than by air pressure, but its characteristics are in many ways similar to the pneumatic clutch. For example, it is applied successfully on power presses and internal combustion engines, although the smaller sizes go well below anything in the air clutch field, down through the machine tool[4] and the fractional horsepower range to miniature sizes (servomechanisms, business machines, etc.). Magnetic friction clutch characteristics paralleling those of the direct-operated air clutch are as follows: (1) fast, smooth engagement, torque building up to the full value in one-tenth of a second or, if desired, pick-up can be prolonged electrically over a period of many seconds. All operations are equally independent of the human variable. (2) Torque can be instantly adjusted to suit while running by means of a rheostat in the magnet circuit, or by electronic control. (3) There are no toggles, yokes, or other wear-prone mechanical actuating parts.

Although magnetically energized clutches require direct current, this usually can be supplied by a rectifier when only ac line power is available. Frequency of adjustment is somewhat greater than for the pneumatic clutch. It is interesting to observe that as the friction linings wear, the torque of the air clutch stays constant, the torque of the mechanical clutch drops off, and the torque of the magnetic friction clutch increases (as a result of the shorter air gap).

The standard magnetically operated clutch is spring released, electrically engaged. This means that like the air clutch, it will "fail safe" and release in case of power interruption. When the clutch is to be used principally as a coupling and will for the most part be engaged continuously, it is customary to specify electrical release, spring set operation. This style affords excellent overload release protection to the driven machine. One of the drawbacks of both the frictional and the positive magnetic clutch, particularly as regards explosive atmospheres, is the need for collector rings, *Fig.* 7. This is overcome in some friction clutches through the use of a stationary magnet, rather than a rotating magnet. This construction has been applied successfully on comparatively heavy, high-speed loads as well as on the lighter loads: the typical construction comprises a fixed magnetic field ring surrounding two rotating armatures and drawing these together by magnetic flux crossing the air gaps. Additional size and weight constitute one disadvantage; another is the added excitation required to offset the lengthened magnetic path.

Centrifugal Clutches: Most centrifugal clutches are of the expanding shoe type, operated either directly by shoe weight, *Fig.* 34, or indirectly by the pressure developed in a mercury-filled rubber gland, *Fig.* 35. Clutches are also built with wedging balls or shoes carried outward by centrifugal force against the restraint of a garter spring. These members, in turn, actuate a disk friction surface, *Fig.* 36.

The expanding shoe principle is applied to advantage in a number of makes of automatic, speed-engaged clutches. Centrifugal force substitutes for cams and levers in energizing the clutch shown in *Fig.* 37 and as a result, construction is considerably simplified and use of multiple short shoes is made practicable, giving uniform lining wear.



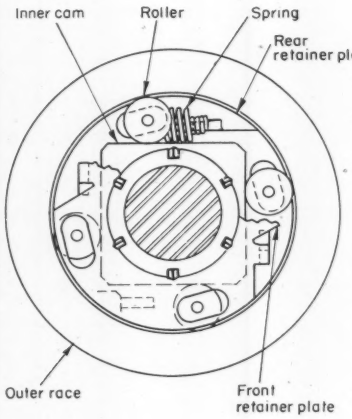


Fig. 39—Cam-and-roller one-way clutch, employs a cylindrical outer race, an inner cam or ramping member, and a set of spring-loaded wedging rollers. The miniature clutch shown has a ¼-in. shaft, and is used in servos, business machines, and other light applications

—Courtesy, High Precision Inc.

Advantages of the mechanical-friction centrifugal clutch include easy starting of high-inertia loads, overload slip protection, and greatly reduced drive motor inrush current, *Fig.* 38. There is, in addition, no slip when running under normal load, and idling drag at low speeds may be completely eliminated by the use of shoe restraint springs designed to engage at some intermediate value, say 40 per cent of full speed. The latter feature has led to numerous installations recently on power lawnmowers, tree-cutting saws, and many other portable engine-driven units.

Other characteristics include low cost (particularly in the smaller sizes), flexible coupling action (usually sufficient to make a supplemental flexible coupling unnecessary), easy adjustment of torque by varying the number of shoes, and automatic wear take-up over the life of the linings.

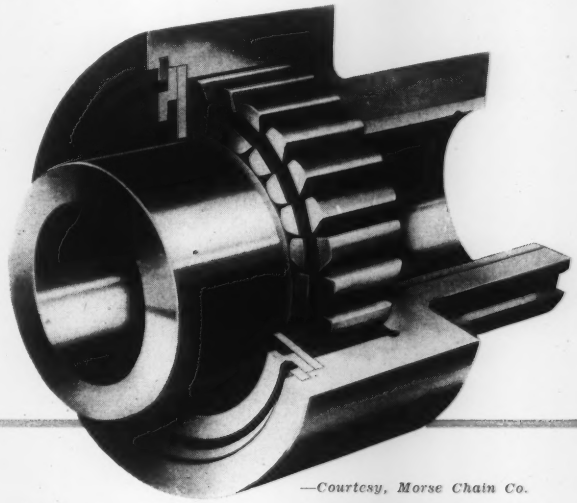
In addition to the familiar application as an engine or electric motor starting clutch, a number of other uses have been developed for centrifugal clutches. For example, they can be installed on each side of the load input shaft in a dual drive to permit freewheeling of the idle prime mover. This arrangement has proved effective on an industrial fire pump, driven normally by an electric motor, but provided with a standby gasoline engine.

Overspeed control is another interesting application. For example, a centrifugal clutch may be mounted on an intermediate-speed shaft of a hoist with its normally driven member coupled to the frame. It will remain disengaged at normal ascent and descent speeds, but will brake the shaft in case of a run-away.

Overrunning Clutches: Many overrunning or one-way clutches are comparatively simple single-purpose designs built by machine manufacturers for intermittent driving service. Typical examples are: pawl-operated machine tool feeds, typewriter ribbon feeds, and lawnmower reel pinion ratchets, all of which are fairly easy to manufacture. In contrast with these, numerous units have been designed which are particularly well suited to high-speed freewheeling. These clutches ratchet by a self-energizing friction wedge action rather than by cut teeth. Typically, they provide stepless engagement, and consequently have been found particularly useful in mechanisms ranging in size from those of the business machine, *Fig.* 39, to stock feeds for power presses. In backstop and freewheeling service, the friction principle is also advantageous in that it secures immediate engagement upon reversal and thereby eliminates the shock that can occur with a toothed ratchet.

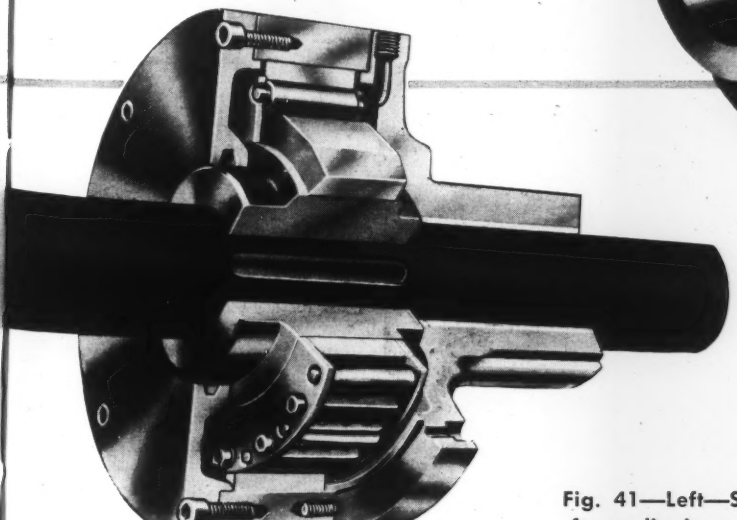
The friction wedge clutches are built in two distinct configurations, the sprag, *Fig.* 40, and the cam-and-roller, *Fig.* 41. Both designs require accurate alignment when employed in axial drives and should be protected in such installations with a supplemental flexible coupling. These are usually supplied by the clutch manufacturers where required.

One unusual variation of the overrunning roller clutch, *Fig.* 42, imparts cyclic rotation to a driven



—*Courtesy, Morse Chain Co.*

Fig. 40—Above—In the sprag-type one-way clutch, dual garter springs keep sprags in light contact with both inner and outer races while freewheeling to assure instant engagement of all sprags upon reversal



—*Courtesy, The Hilliard Corp.*

Fig. 41—Left—Spring reaction against cross-members of an aligning cage maintains roller contact with the cam and outer race of the freewheeling roller clutch

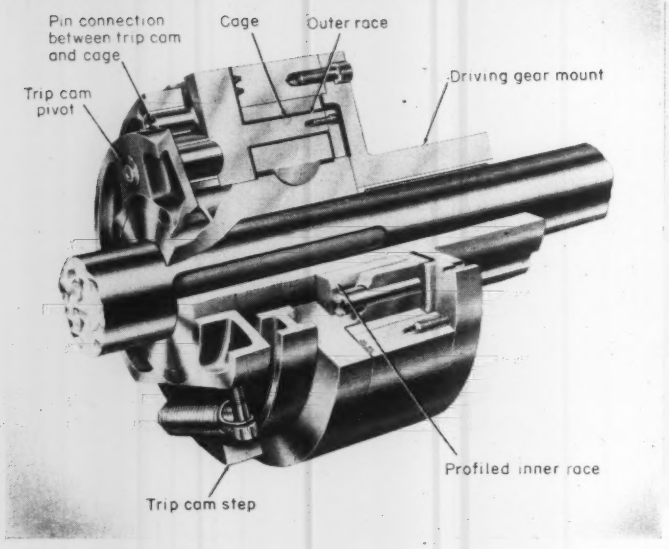


Fig. 42—A gear, sprocket, or pulley drives the hardened and ground outer race of the single-revolution roller clutch. When not transmitting torque, an operating pawl (not shown) rests against the step of a trip cam linked to the roller cage. Momentary release of the pawl allows a tension spring to shift the cage, wedging the rollers between the ramps of the inner cam and the outer driving race. Self reengagement of the pawl stops the trip cam which shifts the rollers away from cam inclines, thus disengaging the clutch

—Courtesy, The Hilliard Corp.

mechanism through trip cam control. Since this clutch is engaged by a sensitive latching mechanism, it may be operated by a comparatively small solenoid and in this form lends itself admirably to remote control. Because it is not ordinarily subject to overheating from frequent application and because it disengages at a predetermined angular position, this clutch is used for cycling, as in a punch press, shear, or nailing machine. By provision of supplemental pawls, it can be disengaged at intermediate points of rotation, giving flexible and simple control for selective angular operation.

The single-revolution roller clutch resembles the positive clutches in many of its characteristics: powerful driving action, quick load pick-up, and suitability for frequent cycling. Likewise, speeds are limited by the inertia forces developed, although the actual load pick-up is somewhat gentler. Because it is unidirectional, it is liable to freewheel if the driven load has a tendency to pull away from the driver at any time, as in a punch press. However, this condition can be counteracted by balancing springs or by a friction brake to retard the driven clutch member.

The wrapped spring clutch, *Fig.* 43, is also used successfully for one-way service. Compared to the wedge type clutches it is less costly, but at the expense of higher backlash and freewheeling drag. Its operating principle is analogous to that of a rope snubbed several turns about a capstan, producing an extremely powerful gripping force through a very light control force. Each wrap of the spring produces approximately a five-fold torque multiplication, depending on the dimensions and shape of the spring coil, the materials in contact, and the presence or absence of oil. Six wraps would, accordingly, produce a 12,000 to 1 amplification. The coils may be either internal or external in friction contact, so that a wide latitude of construction is possible. A tempered steel spring coil and a hardened steel drum are used for the more demanding applications, although cast iron is often a satisfactory drum material and plastics have even been used, on slow, light-duty applications.

Extreme versatility is one of the unusual aspects of this clutch. In its simplest form, a helical spring coiled to fit a shaft lightly will produce one-way clutching action. This construction is used, for example, in the conventional dial telephone[5] permitting the dial to be indexed quickly without dragging the governor. Another typical application is in the Bendix Economat domestic washing machine. Here, alternate operation of pump and agitator is achieved by coupling the pump to one end of the motor shaft and mounting the agitator drive pulley on the other end. A wrapped-spring overrunning clutch is provided for each of the take-offs, so arranged that, when the motor runs in one direction, the pump only is driven, and, when the motor reverses, the agitator only is driven. In this installation the characteristic backlash of the wrapped-spring clutch seems actually beneficial in that it permits the motor to get underway before assuming the load.

To obtain external control of energization, *Fig.* 44, the spring clutch is built with a loosely fitting coil which is brought into engagement by end pressure or by an obstruction placed in the path of the end wrap. High sensitivity can be achieved in this way, as evidenced by the Commander machine tool tapping head which provides a torque transmittal of 1600 lb-in. through a control force of only one ounce.

In summary, the wrapped-spring clutch is sturdy, reliable, and requires no adjustment. It is extremely compact and may be fitted readily into gear hubs and other power transmission elements at low initial cost. Operating factors to be considered are: (1) engagement action is severe, approaching that of a positive clutch; (2) high backlash (1 to 30 degrees) handicaps its usefulness as a ratchet; (3) idling drag torque is reasonably low in externally energized clutches, but must be made comparatively high on the overrunning types. Because of these factors,

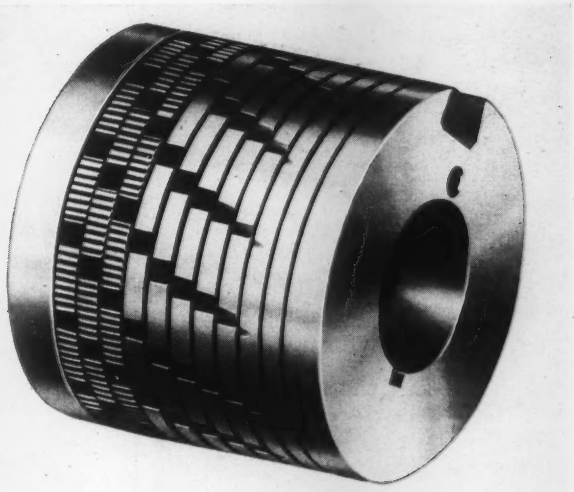


Fig. 43—Driving coil of an expanding-type wrapped spring clutch is rectangular-section wire. The spring edges are bevelled and the surface is serrated to permit escape of the lubricant and minimize slippage

—Courtesy, Marquette Metal Products Co.

most wrapped-spring clutch applications are found in comparatively light machinery, although they have in the past been used for automobile drives (Mercedes) and can be applied effectively on large shafts at low engaging speeds. A successful spring clutch has been built to transmit 8000 horsepower at 50 rpm.

Magnetic Induction Clutches

A number of major clutch designs utilizing magnetic forces have been developed with mechanical contact eliminated except for that in the bearings and collector ring assemblies. One of the simplest magnetic constructions is the hysteresis clutch, consisting typically of a high-hysteresis steel disk located in the field of a power-driven permanent magnet. There are no wires, slip rings, or switches. Salient poles on the driving member induce corresponding magnetic poles within the high-hysteresis driven member; once established, these poles resist displacement and tend to maintain alignment with the driving poles rather than to assume a different relationship. Accordingly, the clutch drives in full couple without heating until the load exceeds the torque rating. When this occurs, the clutch slips, although maintaining a constant output torque and generating heat. Peak operating temperature is the point at which iron loses its magnetic properties, about 1300 F. Speed is limited only by centrifugal stress.

When variable torque is desired, means can be provided for changing the air gap or diverting the flux, as with shorting bars of soft iron. A more flexible method is to substitute rotating electromagnets for the permanent magnets, *Fig.* 45. Operating temperature is thereby limited to 300 F because of coil insulation. On the other hand, maximum torque capacity is raised many times for a given size envelope.

The hysteresis clutch has been found ideal for small torque ratings, down to ounce-inches, because of its smooth action, the absence of idling drag, the close torque control (plus or minus one per cent for a specific energizing current unaffected by environment, slip speed, or aging effects), and the substantially linear torque-current characteristic. Ordinarily, ratings over 1 hp are avoided because the clutch tends to get bulky in large sizes and its amplification ratio is relatively low, on the order of 15 to 1. Because of its unusual characteristics, the hysteresis clutch is being adapted for an increasing number of difficult jobs within its capacity. It has worked out well in constant slipping service, as in dynamometers and tension controls for yarn, film, and fine wire. Other controlled-torque applications include screwdriving machinery and sensitive drilling machines. Variable speed is practical when the load has a rising speed-torque relationship to insure stability, as in centrifugal fans and pumps. Twin clutches driven in opposition are used to make an effective bidirectional servo-actuator. Compared to the ordinary servomotor, this combination provides zero backlash, a fifty-fold reduction of inertia for a given torque, and a four-fold reduction in control current needed.

If a soft iron disk is substituted for the hard steel disk in the hysteresis clutch, an eddy-current drive results. Smooth engagement and drag-free idling are retained, but the other characteristics are fundamentally different. To develop torque, the clutch must slip, and the torque developed increases with the slip as indicated in *Fig.* 46. As a result, the eddy-current clutch is an effective variable-speed drive, operative from full speed to zero (or slightly above, depending on the effect of windage). Torsional damping qualities are excellent.

There are two principal types, air cooled and water cooled. The air cooled type, *Fig.* 47, is customarily

—Courtesy, Marquette Metal Products Co.

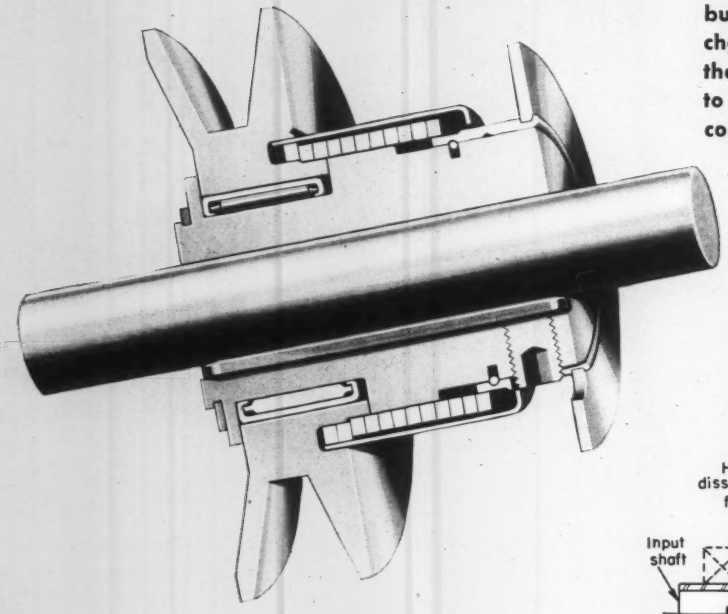
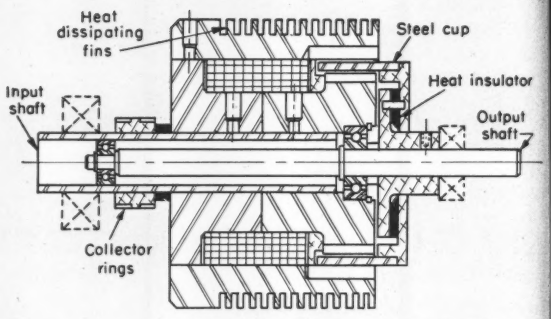


Fig. 44—Left—In a contracting spring clut built into a V-belt pulley, the spring is a chored in the pulley. Operating thrust the shoulder of an actuating sleeve ten to retard the rotating spring, causing it contract and grip the driven memb

Fig. 45—Cooling fins reduce oper ating temperature in the electro magnetic hysteresis clutch. Hea conduction to the steel cup rotor i minimized by an insulating moun



—Courtesy, Duncan & Bayley

supplied in sizes ranging from fractional-horsepower units up to 100 hp at 1800 rpm. Water-cooled clutches are recommended for constant-torque, variable-speed applications from 100 to 18,000 hp. The necessity for water cooling is readily appreciated when it is considered that when output speed is one-third the input, output power is also one-third the input, and the remaining two-thirds input must be liberated as heat within the clutch.

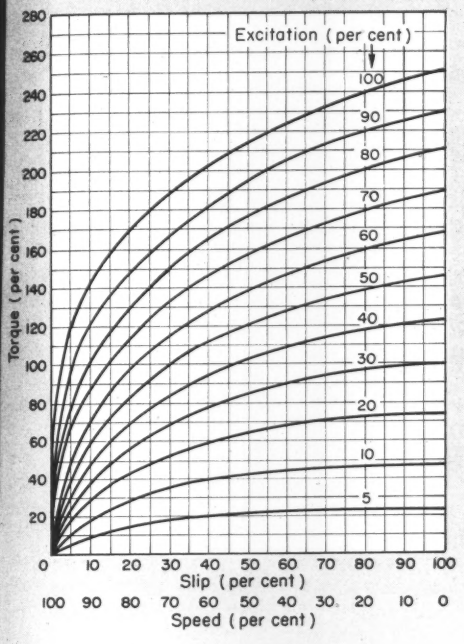
Like other magnetic clutches, the eddy-current clutch requires direct-current excitation. At first glance it might appear that this could be obtained simply with a selenium rectifier or the equivalent, together with a rheostat for speed and torque control. The fact is: in order to maintain satisfactory speed regulation at partial speeds, a coupled tachometer feedback must be provided. The tachometer voltage is fed to an electronic or magnetic amplifier and is there balanced against a reference voltage supplied by a speed control selector. The result is $\pm$ 0.5 per cent speed regulation over a 20 to 1 effective speed control range. Other features can be provided, such as torque limit, speed matching, and controlled load acceleration.

Applications are varied, ranging from servomechanisms to ship propulsion. A representative listing includes drives for automotive fans, generators, tractors, dynamometers, rolling mills, power-presses, oil-well drilling rigs, tension-controls, pumps, and blowers.

In 1948 the National Bureau of Standards announced a new mechanical power transmission device, the magnetic fluid clutch. In its simplest form this consists of two parallel magnetic disks, or two concentric magnetic rings, separated by a thin layer of a lubricated magnetic powder. When the plates are magnetized, the magnetic powder acts as a viscous fluid and will transmit torque from one disk to the other. When high flux densities are imposed, the powder solidifies in effect, spanning the gap between the disks and locking them together.

The magnetic fluid clutch possesses some very unusual properties. It is excellent for small servocontrols because of (1) compactness; (2) extremely fast response rate; (3) low controlling power—such that miniature vacuum tube networks can control as much as ¼-horsepower; (4) essentially linear torque vs. current characteristics—although output torque of early designs varied up to 15 per cent for specific energizations; (5) torque independent of rate of slip; (6) smooth action over the entire torque range; (7) zero creep or slip of load unless higher than torque setting; and (8) in some constructions, very long wear life, of the order of several million operations or better. Inertia is low and rapid cycling is usually permissible (typically to 60 times per minute).

The first clutches tested[6] used iron powder in an oil lubricant. A number of problems soon developed, including separation of the oil and iron, rapid seal wear, and rusting. Idling drag torque was comparatively high, around 4 per cent of full load, and excessive heat developed when the clutch was idled or slipped for any length of time. While solutions have since been found to these problems[7,8], the majority of



—Courtesy, Dynamatic Corp.

Fig. 46—Speed-torque curves for eddy-current clutch indicate performance under different degrees of excitation

magnetic particle clutches marketed today contain a dry mix consisting of iron and graphite or other solid lubricants. The dry clutch is not as smooth as the wet clutch, but it can be built with less drag and substantial heat dissipating ability, even in large integral horsepower sizes, *Fig.* 48. Designs have been made for ratings to 10,000 hp at 1800 rpm.

Hydraulic Clutches and Couplings

Power transmission between driving and driven members is accomplished hydraulically through either hydrostatic force or hydrokinetic force. In general, a hydrostatic clutching device utilizes liquid under high and varying pressures, at comparatively low velocities. The reverse is true of hydrokinetic devices, which maintain essentially constant pressures throughout and produce torque reactions from momentum changes in the fluid.

Hydrostatic forces are utilized in one novel device, *Fig.* 49, which is basically a hydraulic pump having inlet and discharge ports that can be partially or completely blocked by sleeve control valves to create hydrostatic pressure and a proportionate torque reaction. The pump parts consist of a driven rotary

—Courtesy, Dynamatic Corp.

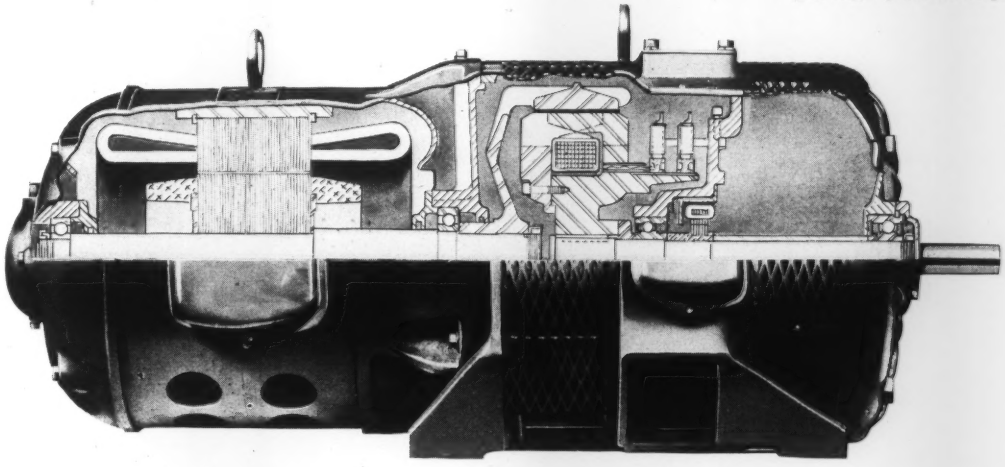


Fig. 47—Combination motor and variable-speed eddy-current magnetic clutch has built-in generator which signals an electronic exciter to control output speed

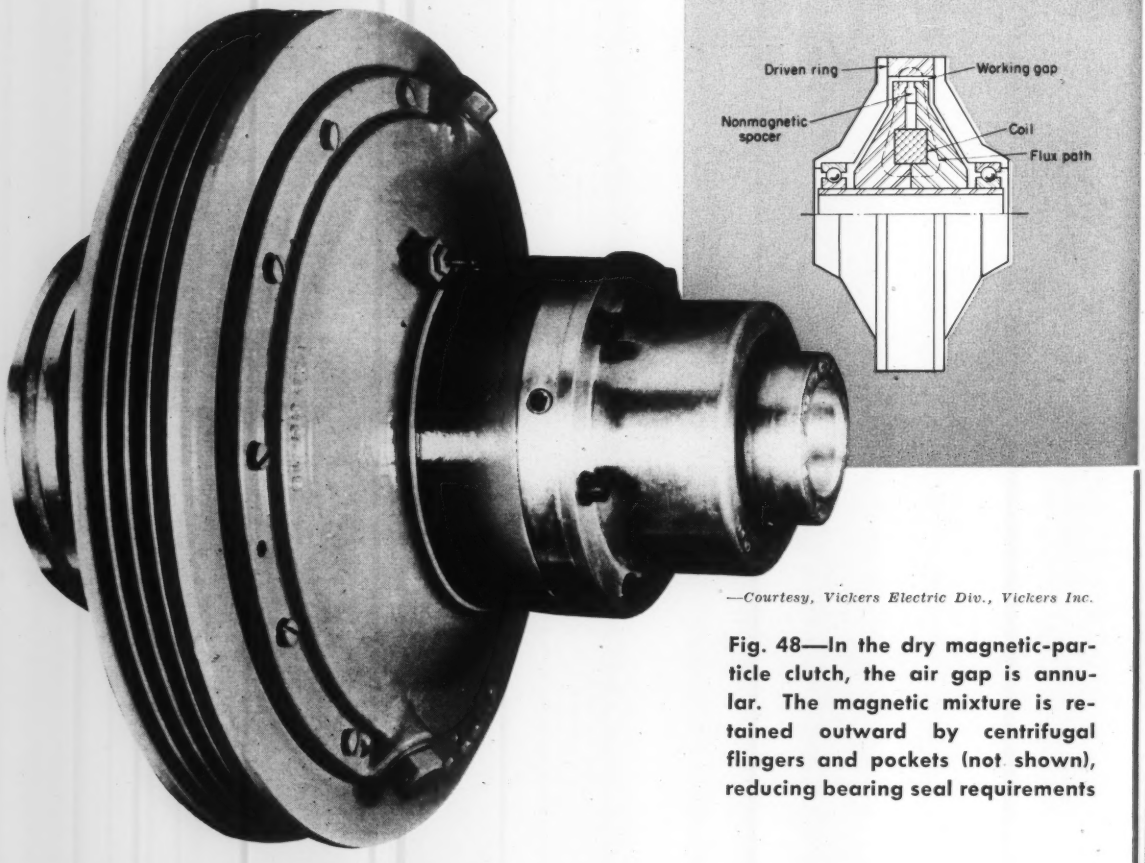
housing carrying planetary gears meshed with a sun gear mounted on the output shaft. A multiple gear pump results, with pumping action being created by a difference in speed between input and output shafts. When the control valves are closed, the pump is blocked and a substantially positive drive results. When the valves are opened slightly, a small amount of oil is permitted to circulate, and output speed drops. Further movement of the valve opens a vent and permits air to circulate with the oil, allowing a considerable speed reduction. To disengage the clutch and permit idling, the valves are moved to an extreme position to shut off the oil and allow free circulation of air. Idling drag torque is thus minimized and heating is avoided.

If desired, relief valves can be provided to limit torque and prevent overload. Since this unit is self-contained and compact, it has found considerable acceptance on heavy-duty traction drives such as small farm tractors, combines, and trench diggers.

Another successful hydrostatic drive arrangement is the combined hydraulic pump and hydraulic motor, *Fig.* 50. The pump is a variable discharge type, to limit heating and torque reaction when idling. Such units are more properly classified as variable-speed drives rather than clutches, and are often specified when a heavy-duty, full-range, closely-controlled, infinitely variable drive is required in addition to the clutch function. The pump-motor combination also offers reversibility with low inertia and quick response, and for this reason is frequently employed in heavy-duty servo drives.

The simplest of the hydrokinetic devices is the traction-type fluid coupling, which consists of nothing more than a centrifugal pump, or impeller, and a turbine wheel, or reactor, facing each other in a housing partially filled with oil. Torque is produced by a difference in speed between impeller and reactor, with approximately 3 per cent slip required to develop full torque. There is no torque multiplication; the prime function is simply to permit the engine or motor to attain a reasonably effective speed at starting, perhaps 70 per cent of full load, before being called upon to deliver the full torque demand of the load. The fluid coupling also eliminates stalling of internal-combustion engines from overload and cushions the drive at all times.

Operation is inherently smooth, and there is no wear, save perhaps on a long-term basis at the shaft seals. On the other hand, drag torque is appreciable at internal-combustion engine idling speeds, and a supplemental friction clutch (which need be specified for light duty only) is necessary to permit the full disengagement usually required for starting the en-



—*Courtesy, Vickers Electric Div., Vickers Inc.*

Fig. 48—In the dry magnetic-particle clutch, the air gap is annular. The magnetic mixture is retained outward by centrifugal flingers and pockets (not shown), reducing bearing seal requirements

gine and for idling over long periods.

The combination of fluid coupling and friction clutch has proved popular in automobiles and is used also in power shovels, spinning mules, and gas-engine industrial trucks. Horsepower capacity is proportional to speed cubed, so that the coupling is not practical at low running speeds, say below 720 rpm. Speeds above 3000 rpm (depending on coupling sizes) are also undesirable, because the heat radiating capacity of the unit is no longer in proportion to its torque transmitting capacity.

When installed in an electric motor drive, the fluid coupling offers many benefits for high inertia loads: (1) the motor and switchgear can be smaller and cheaper, fitted to the running load requirements rather than to the starting requirements; (2) the smaller motor uses less current and runs at a higher power factor; (3) lamp flicker and other disturbances experienced with line starting of large motors are minimized; (4) shock loading of the rest of the drive at starting is eliminated, which means longer life or permits lighter members; (5) easy load acceleration is provided, which is essential for such uses as overhead crane traverse drives; and (6) overload protection is provided for both motor and drive. Should the driven machinery be stalled, the motor speed would be pulled down and the motor protective relays would trip in time to prevent damage to the motor or coupling. By the same token, the drive is isolated and protected from the inertia of the motor armature, and the applied torque is strictly limited to the capacity of the fluid coupling.

In addition to its use on high-inertia loads such as centrifugals extractors and ball mills, the fluid coupling is useful where bearing friction as well as inertia ordinarily compound starting troubles.

Because of heating, the standard traction type fluid coupling is not suited to continued high-rate slippage,

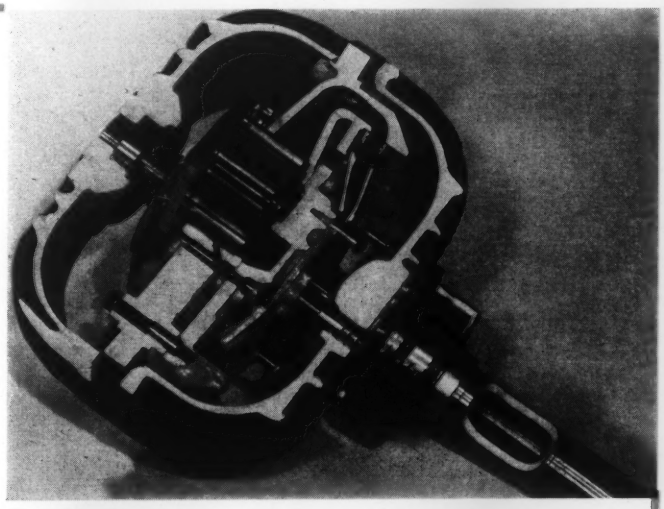


Fig. 49 — Right — Variable-speed, self-contained hydraulic clutch can be slipped for reduced output speeds by bypassing fluid. However, torque capacity is lowered accordingly to prevent overheating

—Courtesy, Thomas Hydraulic Speed Controls Inc

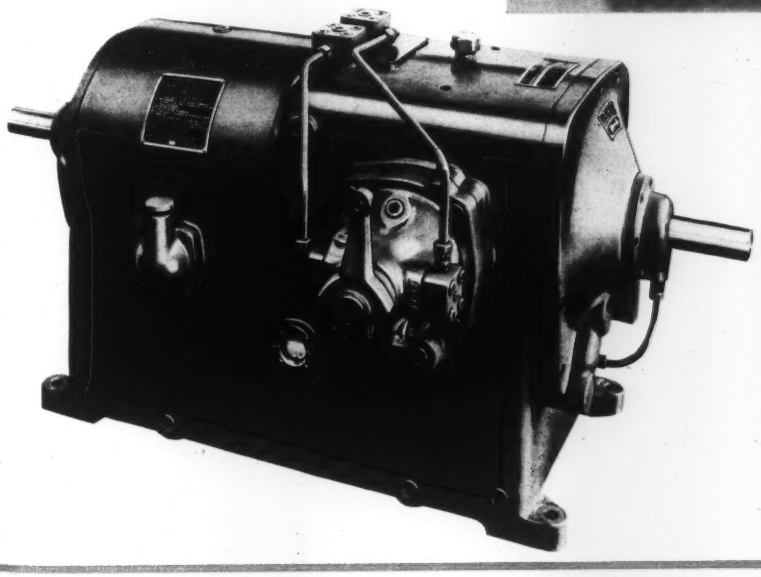
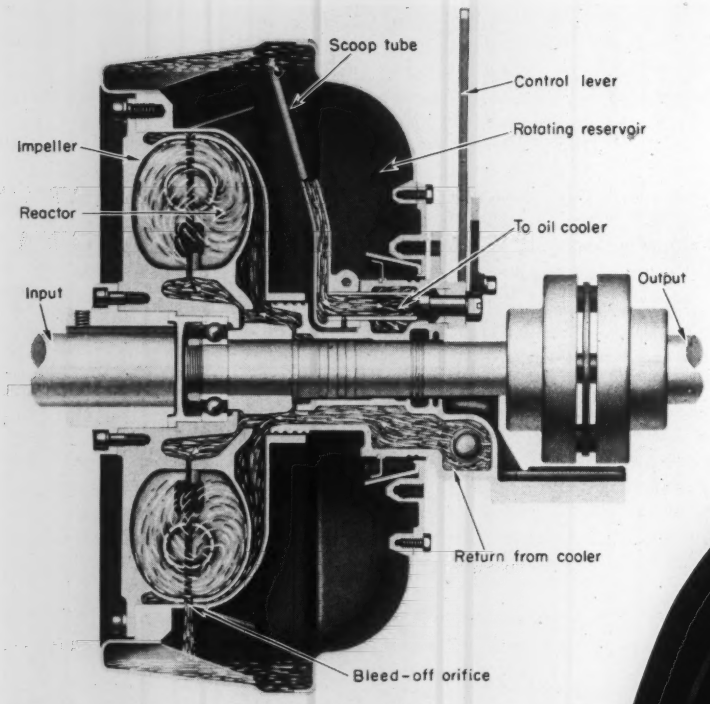


Fig. 50—Left — Hydraulic pump-motor combination provides clutch action although, essentially, it is a constant-torque variable-speed power transmission. The unit is especially suited to applications involving rapid feed change or rapid reversal of rotation; for example, sawmill carriage drives

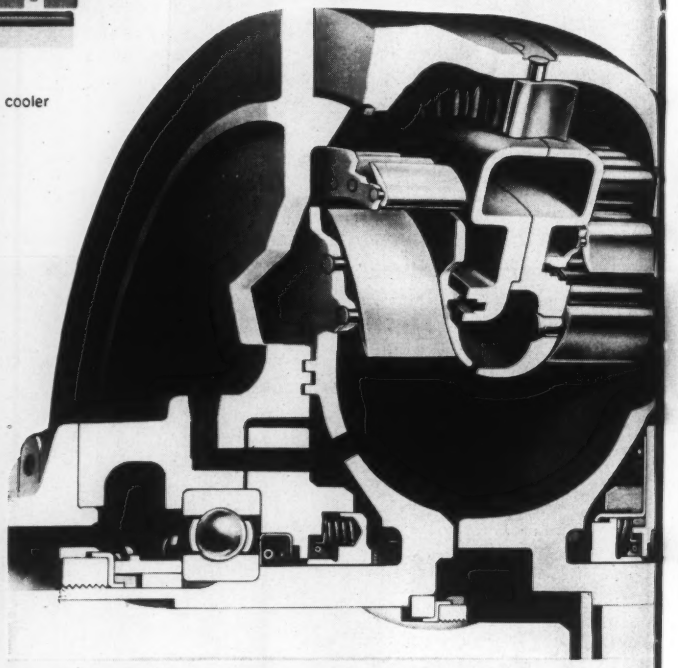
—Courtesy, The Oilgear Co.



—*Courtesy, American Blower Corp.*

Fig. 51—Above — Fluid coupling adapted for clutching and variable-speed operation is controlled by manually or automatically-positioned scoop tube. Oil circulation through a heat exchanger enables temperature control

Fig. 52 — Below — The hydraulic torque converter differs functionally from the simple fluid clutch in that it multiplies output torque. This is accomplished through relatively stationary reactor blades between turbine stages



—*Courtesy, Twin Disc Clutch Co.*

such as would be imposed by starting a heavy load two to three times per minute. One effective solution to this thermal problem is found in circulating the oil continuously through an external oil cooler. This can be done with a pump, or the fluid's own velocity can be utilized, as in a scoop-tube coupling, *Fig.* 51.

The scoop-tube coupling has many possibilities. It has been installed on rolling mills, extruders, and draw benches in order to secure smooth starting, together with adjustable speed and load to match the area of metal being processed. It permits exceedingly slow load accelerations, necessary on certain heavy equipment, and it permits full declutching if desired, usually making a supplemental friction clutch unnecessary when installed on an internal-combustion engine. Engagement requires a minimum of 4 to 10 seconds; full disengagement requires a minimum of 10 to 20 seconds, as oil circulation diminishes.

Continuous full-range variable speed can also be secured in a hydraulic coupling by adding differential gearing to a standard traction coupling, as is done in the Twin Disc Hydro-Wynd. In this design, the impeller and the differential ring gear are bolted together and driven at constant speed. The planet gear spider is attached to the coupling reactor, and the sun gear is part of the output shaft. At zero load, coupling and differential rotate as a unit, with output speed equalling input speed. As the torque demand increases, the output speed slows in proportion until at stall, full torque is developed. There is no torque multiplication; input and output torques are always equal. The gearing ratio is such that at stall, or zero sun gear speed, the spider is moving in the direction of the drive at about 70 per cent full speed. The re-

sultant 30 per cent slip will not cause excessive heating unless stall is prolonged.

Although related closely to the fluid coupling or clutch, the hydraulic torque converter, *Fig.* 52, performs service beyond that ordinarily expected of power transmission clutches. Functionally, it differs from the fluid coupling in that it is capable of multiplying input torque. Initial cost of the hydraulic torque converter is comparatively high and should, therefore, be justified in terms of overall operating characteristics rather than its adaptability for clutching service.

Selection Considerations

From TABLE 1 it is evident that most anticipated clutch requirements can be fulfilled by one or more of the commercially available units indicated. In addition, slight modifications are possible in many of the existing designs to adapt them for special installation and operating conditions. Beyond this, extensive design effort may afford the ultimate solution to a clutch problem. There are, however, many pitfalls and hidden problems likely to be encountered in clutch design that can become rather costly. Therefore, the large degree of experience represented in commercial units should be weighed carefully before entering into the design of a special clutch. Whichever the case may be, numerous factors are to be considered in the selection or design of a clutch.

Capacity Rating: As mentioned previously, a most serious error is the selection of an undersize clutch, which will be a trouble-maker from the beginning. Determination of clutch size involves the application of various factors which allow for the different conditions of service anticipated. To arrive at a final figure, the basic horsepower of the drive should be multiplied in turn by each service factor, resulting in an "equivalent" horsepower nominal rating. Service factors concerning clutch rating appear in TABLE 4.

The nominal ratings of similar clutches made by different manufacturers are not always based on identical standards. Some ratings give the actual torque at which a clutch will slip when properly adjusted; others show the torque or horsepower safely transmitted in service, and may allow as much as 100 per cent safety factor.

On lineshaft installations the load demand may not always be up to the full capacity of the drive; nevertheless, it is good policy to base a lineshaft clutch rating on the full drive capacity, and in some cases to provide for future additional loads. Conversely, new machines sometimes demand greater than normal horsepower during initial running-in periods. This condition should be provided for, however temporary it may be.

Heat Dissipation: If a very fast pick-up is required, despite high inertia, this obviously suggests a clutch with mechanical torque capacity increased proportionally. On the other hand, it might be necessary to provide a smooth, gradual pick-up lasting ten seconds or more, say for a wire drawing machine. An oversize clutch would again be indicated, this time to allow for the heat generated during the period of slip; in addition, the type clutch selected must be capable of close adjustment or possess inherently smooth action and self-adjustment.

If a clutch is operated once per hour or less, it will have adequate time to cool completely before the next engagement. Most catalog ratings are based on this operating frequency. More frequent engagement requires added capacity, often expressed as an extra two per cent for every additional engagement per hour up to 30. If a still higher frequency is anticipated, it is advisable to consult the manufacturer rather than to risk premature clutch failure.

AMBIENT TEMPERATURE: Usually this factor is not taken into account, but it becomes important in clutches designed for continuous slipping service or operated under unusually high or low service temperatures.

Installation Conditions: In addition to basic clutch rating and heat control, there are other miscellaneous points which should be considered in order to assure satisfactory clutch performance at minimum cost. These items materially affect clutch selection and service life.

ALIGNMENT: The average clutch is not a flexible coupling; therefore, to operate properly it must be installed in alignment and so maintained. Adequate bearings should be provided on each side for both radial and thrust loads.

Table 4—Clutch Rating Factors

Service Condition	Rating Factor
Type of Prime Mover	
Electric motor or steam turbine	1.00
Steam engine or 4-cylinder gas engine	1.50
Single-cylinder gas engine	2.00
Type of Load	
Blowers, belt conveyors, generators	1.00
Hoists, heavy-duty lineshafts, rotary kilns	1.50
Crushers, rolling mills, reciprocating conveyors	2.00
Load Inertia Condition*	
Low inertia: low speeds, small pulleys, etc.	0.75 to 1.00
Average inertia	1.00 to 1.25
High inertia: ball mills, etc.	1.50 to 2.00
Clutch Speed (rpm)†	
10	10.00
100	1.00
200	0.50
400	0.25
800	0.12
1200	0.09
1800	0.07

* Low values for load-free starting; high values for starting under load.
† Based on data for an 8-inch single-plate disk clutch.

VERTICAL OPERATION: Most clutches are designed for horizontal service. Vertical operation can impose excessive wear and result in excessive idling drag and wear unless provisions for this condition are made to counteract unbalanced weight.

PROLONGED IDLING: Adequate provision must be made for prolonged high-speed idling. In this respect it is good practice to install a clutch so that the actuating mechanism is stationary while the clutch is disengaged.

DAMPNESS: In addition to rusting, a friction clutch may be subject to friction coefficient variation under damp conditions and may either slip or grab, depending on the friction material. There are, of course, at least two ways of combating this condition, powder-metal friction material and wet operation, as discussed previously.

DUST AND DIRT: Dust causes friction elements to wear rapidly. Dirt and lint can also foul operating mechanisms. Adequate sealing will avoid these conditions.

OIL: The presence of oil in normally dry clutches lowers the coefficient of friction and causes dirt accumulation. Effective oil seals will, of course, prevent this.

FIRE HAZARD: If conditions are sufficiently critical to warrant the use of explosionproof electrical apparatus, similar precaution should be observed in selecting a clutch.

MAINTENANCE: Convenient access for periodic servicing and maintenance should be provided in all installations to avoid unusual demands on clutch durability.

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American Felt Co. ..... **Glennville, Conn.**	**The Minster Machine Co.** ..... **Minster, Ohio**
The Cincinnati Shaper Co. ..... **Cincinnati, Ohio**	**The Prosperity Co. Inc.** ..... **Syracuse, N. Y.**
Cleveland Punch & Shear Wks. ... **Cleveland, Ohio**	**Mr. Jacob Rabinow, U. S. Bureau of Standards** ..... **Washington, D. C.**
Commander Mfg. Co. ..... **Chicago 24, Ill.**	**Ramsey Winch Mfg. Co.** ..... **Tulsa, Okla.**
General Motors Corp., Diesel Engine Div. ..... **Detroit, Mich.**	**Raybestos-Manhattan Inc.** ..... **Chicago 11, Ill.**
R. G. LeTourneau Inc. ..... **Peoria, Ill.**	**Reuland Electric Co.** ..... **Alhambra, Calif.**
Magnetic Fluid Corp. 41 Tuscan Rd., Maplewood, N. J.	**The U. S. Graphite Co.** ..... **Saginaw, Mich.**
	S. K. Wellman Co. ..... **Cleveland, Ohio**

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DESIGNING MECHANICAL COMPUTERS

Part 2—Functions Having more than Two Independent Variables

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EXPANSION of tabular functions of two variables into algebraic structures of one-variable functions were discussed in the preceding article (M. D., July 1952). These structures have the advantage of great compactness—compared to the conventional expansions into series of orthogonal functions—and are therefore well adapted for representation by analog computers. This part deals with the expansion of functions of many independent variables, using similarly compact structures adapted to analog representation. This is a more important problem since such expansions are the only means for representing many-variable functions by analogs. Representations of functions of many variables by solid cams are, of course, impossible because real space has only three independent dimensions.

Where functions of more than three independent variables are mentioned, the numerical subscripts 1, 2, . . . , n, in $f(x_1, x_2, \ldots, x_n)$ are used to identify the different independent variables. Where three or less independent variables are involved, different letters are used to distinguish the variables, e.g., the x and y in $f(x_i, y_j)$. The lower-case subscripts—the running indexes of the independent variables—are included to assist in interpreting an example which appears later in this article.

Direct expansion of functions of three variables into such forms as*

$$f(x_i, y_j, z_k) \doteq g(x_i) + h(y_j) + u(z_k) + g'(x_i)\, h'(y_j) + g''(x_i)\, u'(z_k) + h''(y_j)\, u''(z_k) + g'''(x_i)\, h'''(y_j)\, u'''(z_k) \quad (19)$$

can be carried out by extensions of the methods given in Part I. The computing routines become laborious, however, and further difficulties arise from the large number of possible structures, from which the most compact structure should be selected. This direct approach is probably not practical when more than two independent variables are involved.

There is, fortunately, a two-stage expansion which is both simple enough to make the calculations practical, and compact enough to make the corresponding analog computer practical. It has been used for arbitrary functions of as many as five variables, with encouraging success.

In direct analogy to Expression 2 in Part 1, a function of n variables may be expanded into a sum of one-variable functions, plus a residual:

$$f(x_1, x_2, \ldots, x_n) = f_1(x_1) + f_2(x_2) + \ldots + f_n(x_n) + R(x_1, x_2, \ldots, x_n) \quad (20)$$

The formulas for the one-variable functions are similar to Expressions 6*a* and 6*b* of Part 1; the i-th value of the approximating function of $f_p(x_p)$ of the p-th variable, x_p, is simply the average of all the values of $f(x_1, x_2, \ldots, x_n)$ in which x_p has its i-th value.

In the case of three independent variables x_i, y_j, z_k,

*The conventions of Part I, such as the use of lower-case letters to indicate functions adjusted to zero mean, are used without change in this part.

the equation corresponding to Expression 20 would be

$$f(x_i, y_j, z_k) = f_1(x_i) + f_2(y_j) + f_3(z_k) + R(x_i, y_j, z_k) \quad \ldots\ldots (21)$$

Fig. 4 illustrates graphically the averaging processes which are involved for three independent variables. Here the values of $f(x_i, y_j, z_k)$ are represented by blocks in a rectangular pile four blocks wide (corresponding to the four assumed values of x_i), three blocks deep (corresponding to the three assumed values of y_j), and five blocks high (corresponding to the five assumed values of z_k). The fifth value $f_3(z_5)$ of the approximating function $f_3(z_k)$ is the average of the top layer of f's (which have been completely outlined to show them more clearly). In algebraic form,

$$f_3(z_5) = \frac{1}{12} \sum_{i=1}^{4} \sum_{j=1}^{3} f(x_i, y_j, z_5) \quad \ldots\ldots (22)$$

At this point, the development breaks away from that of Part 1. Instead of expanding the residual $R(x_1, x_2, \ldots, x_n)$ in Expression 20 into a sum of products of one-variable functions, as was indicated in the approximation in Expression 19, the residual, R, is expanded into a sum of arbitrary functions of the variables by pairs, plus a residual, R':

$$R(x_1, x_2, \ldots, x_n) = f_{12}(x_1, x_2) + f_{13}(x_1, x_3) + \ldots + f_{23}(x_2, x_3) + f_{24}(x_2, x_4) + \ldots + f_{n-1,\,n}(x_{n-1}, x_n) + R'(x_1, x_2, \ldots, x_n) \quad \ldots\ldots (23)$$

These two-variable functions are again averages over the unspecified variables. That is, the value of the function $f_{pq}(x_p, x_q)$ at the point (i-th value of x_p, j-th value of x_q) is simply the average of all the values of the residual R in which x_p has its i-th value and x_q has its j-th value.

In the illustrative case, *Fig.* 4, of three independent variables, the equation corresponding to Expression 23 is

$$R(x_i, y_j, z_k) = f_{12}(x_i, y_j) + f_{13}(x_i, z_k) + f_{23}(y_j, z_k) + R'(x_i, y_j, z_k) \quad \ldots\ldots (24)$$

The value of $f_{23}(y_j, z_k)$ at $j = 2, k = 1$, for instance, is simply the average of the four values of $R(x, y, z)$ in the row (dotted in *Fig.* 4) starting at the middle of the bottom row of the (y, z) plane, and going out parallel to the axis of x. Algebraically,

$$f_{23}(y_2, z_1) = \frac{1}{4} \sum_{i=1}^{4} R(x_i, y_2, z_1) \quad \ldots\ldots (25)$$

The residual, R' of Expression 23, left after this expansion into functions of two variables, can be expanded in turn into functions of three variables, and so on. Mr. N. P. Cedrone, of Raytheon, has shown in an unpublished study that the residuals from this expansion are least squares, as compared to any other expansion into functions of one variable plus functions of two variables, etc.

This expansion is identical in algebraic form with the "analysis-of-variance" expansion used by the statisticians in the interpretation of experimental data. Anyone planning to carry out an expansion such as this would be well advised to read the chapters on analysis of variance, especially those on multiple analysis, in any of the good statistical texts now available.

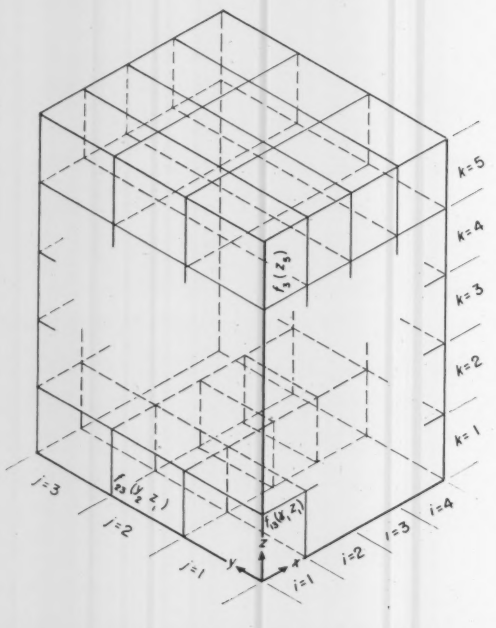
Fortunately for the computer designer, many of the functions encountered in actual practice result in expansions of this form which converge exceedingly rapidly, so that the residual R' (see Expressions 23 and 24), from the set of functions of two variables, is usually negligible. In addition, many of the functions of two variables may be so small that very crude approximations to them in the construction of the computer will be adequate. Once these functions of two variables have been calculated, they may be expanded into sums of products of functions of one variable, by the methods given in Part 1, if the designer wishes.

One advantage of this approach to the expansion of functions of many variables is that exact numbers for the error committed in neglecting any function or set of functions appear automatically from the condensed form of the calculations given in statistics texts. Kendall[5] has proved for two independent variables, that

$$\sum_i \sum_j [f^2(x_i, y_j) - f_1{}^2(x_i) - f_2{}^2(y_j) - f_{12}{}^2(x_i, y_j)] \equiv 0 \quad \ldots\ldots (26)$$

and corresponding equations for larger numbers of

Fig. 4—Geometric interpretation of summations



[5]References are tabulated at end of article.

independent variables. By a simple modification of Kendall's proof where the mean value of $f(x_i\ y_j)$ is initially adjusted to zero,

$$\sum_i \sum_j [f(x_i, y_j) - f_1(x_i) - f_2(y_j)]^2 =$$

$$\sum_i \sum_j [f^2(x_i, y_j) - f_1^2(x_i) - f_2^2(y_j)] =$$

$$\sum_i \sum_j f_{12}^2(x_i, y_j) \quad \ldots\ldots (27)$$

Dividing through by the number of entries in the table defining $f(x_1, x_2, \ldots, x_n)$, Expression 27, i.e., the equivalent for n variables, leads to the statement that the mean-square error committed by neglecting one or more functions from a complete expansion of this type is simply the sum of the mean-square values of the individual functions which were neglected. To illustrate, if a computer designer decides that, from a complete expansion, he will neglect three functions whose mean-square values are 7, 26, and 82, respectively, the mean-square error of approximation will be $7 + 26 + 82 = 115$, in units squared (where the units are those that describe the original function). Similarly, the error committed by stopping an expansion at any point, and neglecting *all* the remaining functions, is simply the difference between the mean-square value of the original function and the sum of the mean-square values of the approximating functions already determined. The value of this insight into the progress of an expansion can hardly be exaggerated.

To give an illustration of a function of five variables which might be encountered, the airspeed F of a certain airplane might be the function

$$F = F(x_1, x_2, x_3, x_4, x_5) \quad \ldots\ldots (28)$$

where x_1 is power setting, x_2 is gross weight, x_3 is air density, x_4 is cowl - flap setting and x_5 is trim - tab setting. Suppose this function to be tabulated, (from theory or from the results of an experiment) at i values of x_1, j of x_2, k of x_3, p of x_4 and q of x_5. The method of expansion of this function of five independent variables into arbitrary functions follows:

As was done for the illustrative two-variable function (Part 1, TABLES 1 and 2), the mean value

$$F_o = \frac{1}{ijkpq} \sum_1^i \sum_1^j \sum_1^k \sum_1^p \sum_1^q F \quad \ldots\ldots (29)$$

should first be determined. Then the next equation is

$$f(x_1, x_2, x_3, x_4, x_5) = F - F_o$$
$$= f_1(x_1) + f_2(x_2) + f_3(x_3) +$$
$$f_4(x_4) + f_5(x_5) +$$
$$R(x_1, x_2, x_3, x_4, x_5) \quad \ldots\ldots (30)$$

in analogy to Expression 21 of the three-variable example. Here again, the formulas for these one-variable functions are very similar to Expressions 6*a* and 6*b* of Part I, and the formulas can be developed in the manner illustrated in the Appendix to Part I.

The equation analagous to Expression 24 is

$$R(x_1, x_2, x_3, x_4, x_5) = f_{12}(x_1, x_2) + f_{13}(x_1, x_3) +$$
$$f_{14}(x_1, x_4) + f_{15}(x_1, x_5) +$$
$$f_{23}(x_2, x_3) + f_{24}(x_2, x_4) +$$
$$f_{25}(x_2, x_5) + f_{34}(x_3, x_4) +$$
$$f_{35}(x_3, x_5) + f_{45}(x_4, x_5) +$$
$$R'(x_1, x_2, x_3, x_4, x_5) \quad \ldots\ldots (31)$$

The formulas for these two-variable functions can again be derived by using the methods of the Appendix to Part I, or, what is the same thing, the two-variable functions may be found by carrying out an analysis-of-variance as described in any good statistical text.

By combination of Expressions 30 and 31, and using a shorthand notation—writing f_{12} for $f_{12}(x_1, x_2)$, for instance,

$$f = f_1 + f_2 + f_3 + f_4 + f_5 + f_{12} + f_{13} +$$
$$f_{14} + f_{15} + f_{23} + f_{24} + f_{25} + f_{34} +$$
$$f_{35} + f_{45} + R' \quad \ldots\ldots (32)$$

It is entirely possible, and even probable, that, if the airspeed function were expanded as in Expression 32, R' would be negligible. TABLE 6 shows the results of carrying a typical five-variable expansion, such as the airspeed problem, through the functions of two variables, i.e., as far as indicated in Expres-

Table 6—Variance Distribution of a Typical Function of Five Variables

Total Variance $V(f)$ =	88,940.95
Functions of the Variables Singly:	
$V(f_1)$ =	79,319.84
$V(f_2)$ =	322.46
$V(f_3)$ =	410.02
$V(f_4)$ =	8,762.32
$V(f_5)$ =	96.36
Subtotal =	88,911.00
Functions of the Variables by Pairs:	
$V(f_{12})$ =	9.79
$V(f_{13})$ =	12.00
$V(f_{14})$ =	0.20
$V(f_{15})$ =	2.74
$V(f_{23})$ =	0.18
$V(f_{24})$ =	0.02
$V(f_{25})$ =	0.03
$V(f_{34})$ =	0.64
$V(f_{35})$ =	3.88
$V(f_{45})$ =	0.01
Subtotal =	29.49
Total =	88,940.49
Residual $V(R')$ =	0.46
Total Variance $V(f)$ =	88,940.95 (CHECK)

sion 32. The residual is indicated as $V(R^1)$

Rather than writing out the functions f_1, f_2, etc., in this example, which would be unwieldy, TABLE 6 expresses the "size" of the functions in terms of their variance V (refer to Expressions 16 and 16*a*, Part I).

For instance,

$$V(f) = 88{,}940.95 = \sum_{1}^{i}\sum_{1}^{j}\sum_{1}^{k}\sum_{1}^{p}\sum_{1}^{q} (f)^2 \quad \ldots\ldots\ldots\ldots (33a)$$

and also

$$V(f_{34}) = 0.64 = ijq \sum_{1}^{k}\sum_{1}^{p} f_{34}{}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (33b)$$

and so forth. The residual, after functions singly and by pairs have been removed, is very small as shown at the bottom of TABLE 6:

$$V(R') = 0.46 = \sum_{1}^{i}\sum_{1}^{j}\sum_{1}^{k}\sum_{1}^{p}\sum_{1}^{q} (R')^2 \quad \ldots\ldots\ldots\ldots\ldots (34)$$

To illustrate further, if R' is omitted and then five flat cams and 10 solid cams are built, according to the functions derived by the expansion, and their outputs summed as in Expression 32, the root-mean-square error in output (excluding errors arising from tolerances) will be only $\sqrt{0.46/88{,}940.95} = 0.0023$ or 0.23 per cent.

Thus, in this case, a function of five independent variables (which is impossible to handle as one unit, since a single cam can reproduce at most a function of two independent variables) is approximated closely by 15 cams, plus adding mechanisms, all of which are possible to construct. All functions of several independent variables will not be approximated so closely by the analysis-of-variance expansion as was this one (cf., the example in the previous article, although the comparison is somewhat unfair, since that example was purposely set up so as to be difficult to approximate closely). A good percentage of the natural (i.e., physical) functions of several independent variables, will lend themselves to this treatment, however, and the resulting approximation will be very good. This particular function (from which TABLE 6 was derived), turned out to be very closely the sum of the functions of the variables singly; all functions will not be like this, although the sum of the functions of the variables singly will usually account for well over half of the total variance.

It is noted that the solid cams mentioned could be made relatively small and with loose tolerances since they are required to reproduce only small parts of the total function; for instance, f_{14} of TABLE 6 contributes only 0.20 to the total variance, while f_4 contributes over 8000. If manufacturing to the same order of physical size then, the tolerances on the f_{14} cam could be correspondingly looser than those for the f_4 cam.

Because of Expressions 26 and 27, the computer designer knows the exact cost, in terms of increased error of approximation, of omitting one or more of the smaller functions from his computer. The number of functions omitted is determined by a balance between the cost of constructing both the function units and the adders required to represent the smaller functions, and the cost of error arising from their omission.

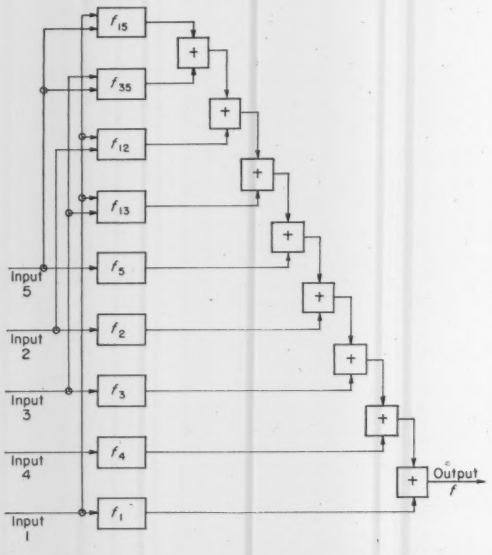
If, for instance, it is required to reproduce the function from which TABLE 6 was derived, to an accuracy of one per cent root-mean-square, the squared error in output can be as high as 8.89, since $\sqrt{8.89/88{,}940.95} = 0.01$ or one per cent. Since $R' = 0.46$, a total squared-error of $8.89 - 0.46 = 8.43$ is allowed, to be taken up by the omission of functions from the expansion and by errors arising from physical tolerances. In actual construction, at least the functions f_{45}, f_{24}, f_{25}, f_{23}, f_{14}, and f_{34} would be omitted (and their omission would be considered in that order—the order of increasing size). The squared output-error arising from the mathematical approximations would be

$$R' + V(f_{45}) + V(f_{24}) + V(f_{25}) + V(f_{23}) + V(f_{14}) + V(f_{34}) = 1.54$$

This would leave a squared error of $8.89 - 1.54 = 7.35$ to be taken up by tolerances. The block diagram of such a computer is shown in *Fig.* 5. In terms of cams, five flat cams, four solid cams and eight adding mechanisms are required to approximate the original function. The root-mean-square error in approximation is only $\sqrt{1.54/88{,}940.95} = 0.0042$ or 0.42 per cent. It should be noted, in *Fig.* 5, that the functions are summed in order of increasing size—the largest function, f_1, is summed toward the total f via only one adding mechanism, so that the effects of errors arising from tolerances in the adder chain are minimized.

Alternatively, the solid cams could be replaced by structures based on the product-of-functions approxi-

Fig. 5—Computer block diagram



mation of the previous article. Again in terms of cams, the resulting computer would now contain a maximum of 13 flat cams, four multiplying mechanisms and eight adding mechanisms, solid function-cams now being unnecessary. The final computer would have a squared error (arising from mathematical approximations) slightly greater, though probably not much greater, than the 1.54 discussed previously. This increase in error, of course, arises from the products-of-functions structures (see Part 1).

Practical computers for functions of five or six variables, for example, are possible because almost every function arising from a reasonable physical situation, when expanded by the analysis-of-variance form, requires for its representation only the functions of the variables singly, some of the functions of the variables by pairs, and occasionally one function of three variables. Cases will occur where the functions of the variables by triples or quadruples are important. In most cases, these functions can be approximated closely by products of functions of the component variables singly (discussed in Part I). Where the labor is justified, two serial expansions into such products of functions will usually be adequate. Although the iterative solution of the equations for such a form as

$$f_{1234}(w, x, y, z) \doteq g(w)\, h(x)\, r(y)\, s(z) + g'(w)\, h'(x)\, r'(y)\, s'(z) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (35)$$

is laborious, and leads to computers with correspondingly many parts. Other approaches, such as expansion in orthogonal functions (e.g., Fourier Series), will usually lead to even more difficult constructions.

The representation of the functions of two or more variables in the analysis-of-variance form, by physical analogies, leads to the same considerations of engineering design as were discussed in the introduction to Part I. While star-grid generators[6], variations on Bennett or Goldberg[7] linkages, or solid cams may be used, it is usually true that the total cost of design and construction will be lowest if the many-variable functions are approximated by structures of arbitrary functions of the variables singly, followed by representation of these structures by linkages or other function units, with the associated operators such as adders, multipliers, etc.

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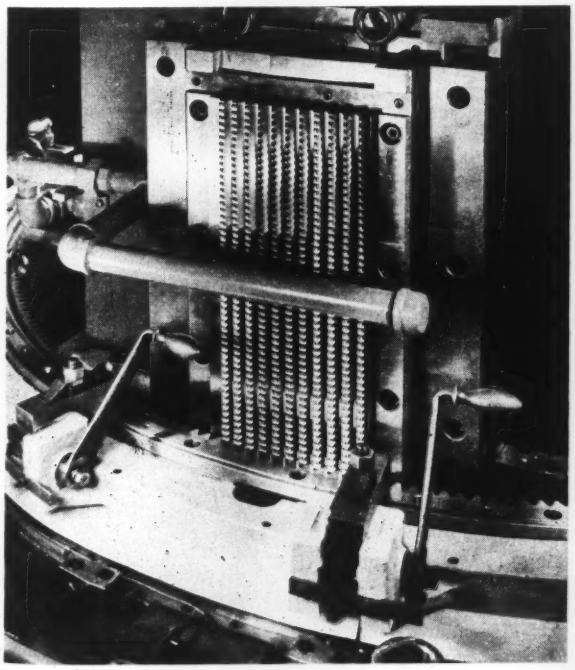
Broach Speeds Gear Cutting

REDESIGN of an existing vertical surface-broaching machine to operate virtually inside a six-foot diameter gun turret ring-gear has resulted in increased production with substantially reduced capital investment.



To enable simultaneous broaching of eleven 4-pitch tooth spaces, an indexing fixture designed to encircle the column of the machine has been added. Hydraulic power equipment originally housed in the column is now rearranged with additional controls to form a compact floor-mounted unit.

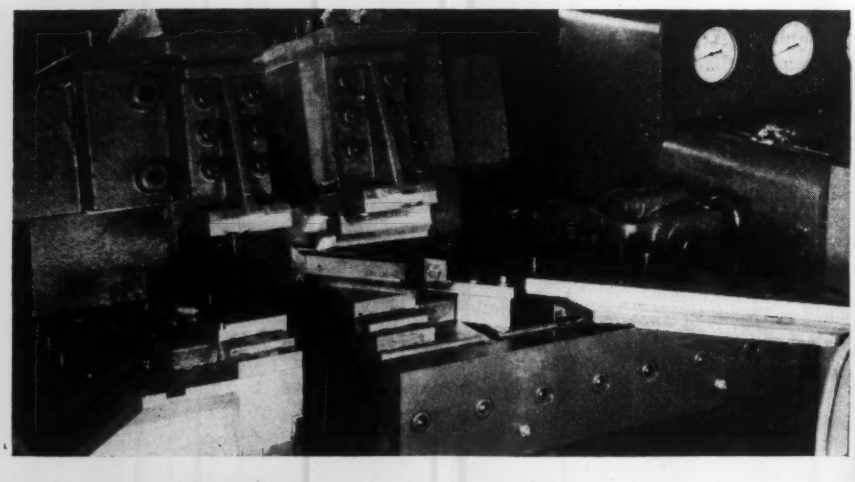
The gear blank is held by a series of lever-operated toe clamps in the rotary fixture which is indexed by a hydraulic cylinder, and positioned by a master locating plunger. The 4-ton fixture is supported partly by rollers at the sides of the column to permit easier shuttle action which is necessary to clear the broach of the work on the return stroke. Shuttle movement is effected through a hydraulically controlled locking cam action tied in with ram operation.

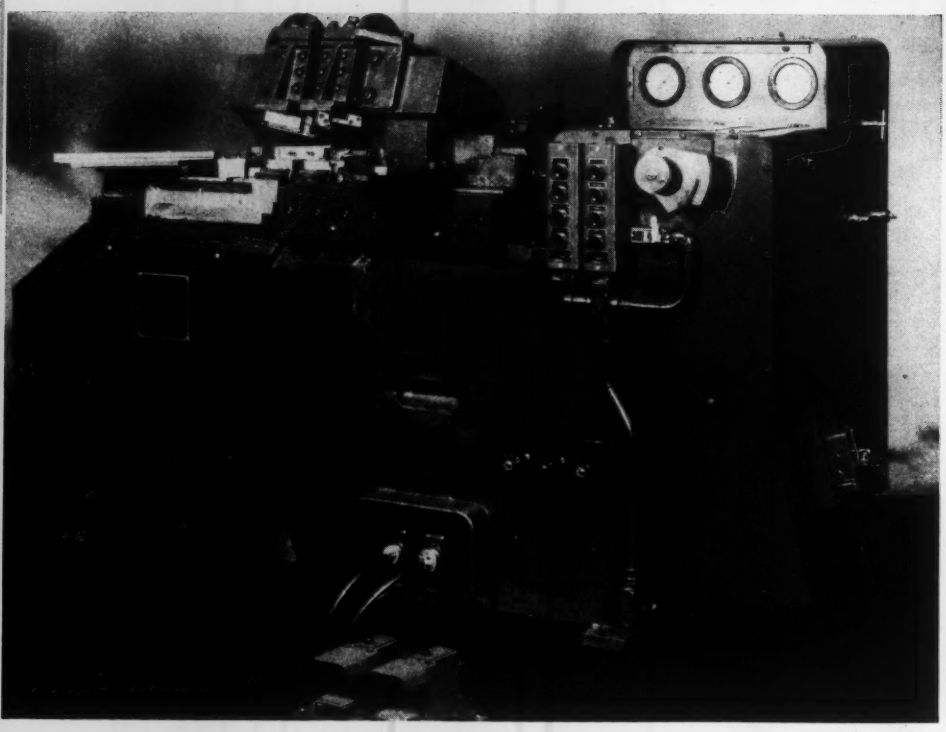
Built by Colonial Broach Co., the machine broaches 294 teeth in thirty minutes with tooth spacing accurate within 0.001-inch. By former methods, the same operation required 4½ hours. According to Army Ordnance officials, the machine has reduced cost of the rings $400 per day on a comparative basis and represents the solution to a serious bottleneck in the current tank program.

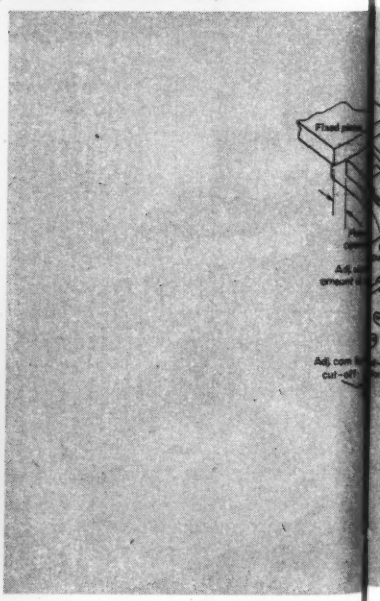
"It is reasonable to believe that within the next few years the Russians, like ourselves, will be flying planes with power plants that are capable of doubling the thrust of present day engines."—R. L. GILPATRIC, *under secretary, U. S. Air Force*

Welder Pinches Off Flash

TWO important functions in flash welding, flashing and upset, are synchronized automatically by a unique mechanism combining pneumatics, hydraulics, and mechanical linkages in the Thomson Synchro-Matic welder, bottom, left. Additionally, an exclusive design of the clamping dies, below, left, makes possible the automatic removal of welding flash in nonferrous metals. Photo, below,



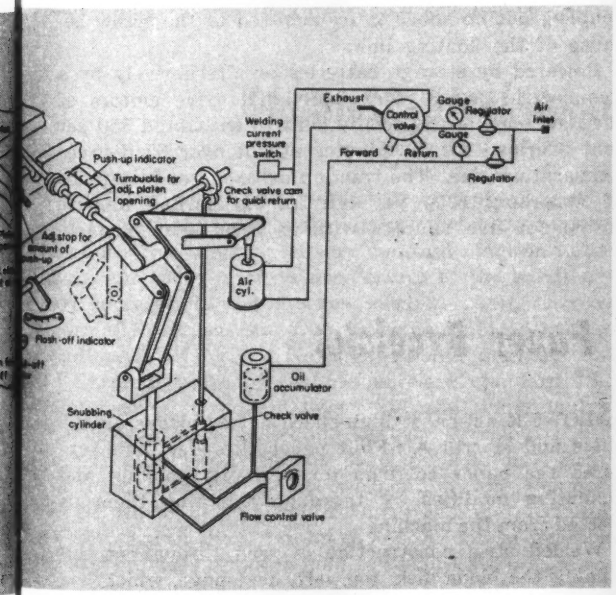




typifies this result, showing comparative corners of an aluminum window frame as welded with and without flash removal.

Sections to be welded are located in the aligning dies and secured by air-operated rocker clamps through pedal control stations. One die setup is mounted on a stationary platen insulated from the machine bed. The other is on a traversing platen which is shifted to produce the welding flash gap and subsequent pressure-formed joint. The movable platen slides on hardened and ground steel wear plates.

Welding cycle control elements are illustrated in the schematic diagram, below. Rotated by a manually controlled double-acting air cylinder, a crankshaft actuates the movable platen during the welding cycle through an adjustable-length connecting rod. Platen velocity is retarded during the "flash-off" phase of the cycle by a throttle-controlled hydraulic snubbing cylinder coupled to the crankshaft through an over-center toggle linkage. This produces relatively slow but accelerated platen motion up to dead-center position of the toggle links. At this point an adjustable cam on the crankshaft trips a limit switch to shut off the welding current. Simultaneously, a second cam opens a throttle bypass valve in the hydraulic circuit to cancel snubbing action and permit continued advance of the platen rapidly to a positive stop.

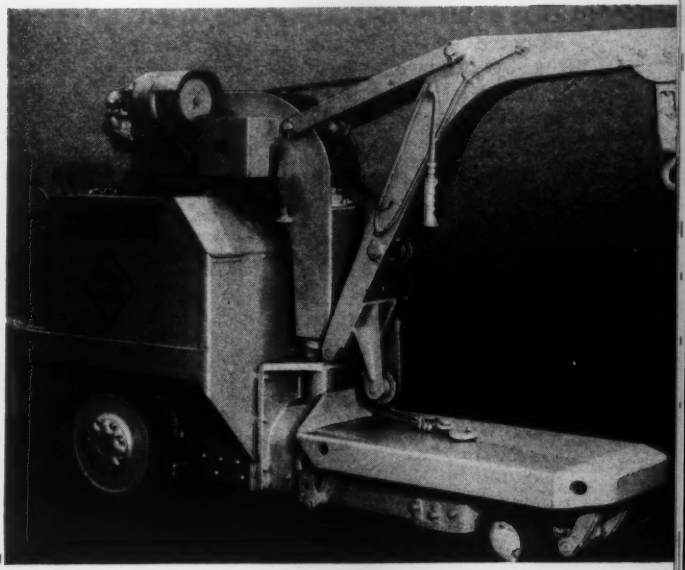


During rapid platen traverse, heated ends of the work pieces are "pushed-up" between the dies. Tapered leading edges of the dies nearly touch when the positive stop is reached. This necks the pushed up metal to a minimum thickness adjacent to the joint so that it breaks off clean when the dies open, and can be removed neatly with minimum effort.

On return stroke of the platen, the bypass valve in the snubbing circuit remains open to speed reset action. Oil in the snubbing circuit reservoir is pressurized at all times by a regulated air supply. A Vickers flow-control valve enables infinite speed adjustment of the snubbing piston over a 20 to 1 range for preselecting flashing speed. Indicator scales provided for all setup and control adjustments minimize make-ready time when duplicating previous operations.

Industrial Truck Serves Triple Duty

MAXIMUM utility has been designed into a new combination low-lift platform industrial truck and crane, below, designed by the Elwell-Parker Electric Co. particularly for plant maintenance operations and out-of-the-ordinary materials handling requirements. In addition to crane and pallet loading of the platform, skid loading is convenienced through a powered



winch built into the boom assembly of the crane.

All operating functions are controllable from the conventional operator station. Alternatively, winch and crane pushbutton switches in a convenient cylindrical pendant station cable-attached to the crane boom enable on-the-floor control for increased flexibility.

Of welded steel construction, the 2000-lb capacity boom may be swivelled 90 degrees either way from center for hoisting and winching operations. Positioning control of the boom is provided through a lever-operated friction brake, built into the column bearing, which has a positive locking key to maintain central position of the boom during transit.

Mounted on three parallel links, the platform is lifted by a powered-nut elevating screw, top, left, coupled underside at the rear end through a floating link. Rotation of the nut pulls the platform back and upward according to swing permitted by the parallel links. Platform loads in excess of the standard 4000-lb capacity are prevented by spring-loaded friction engagement of the elevating nut with the worm gear of the nut drive.

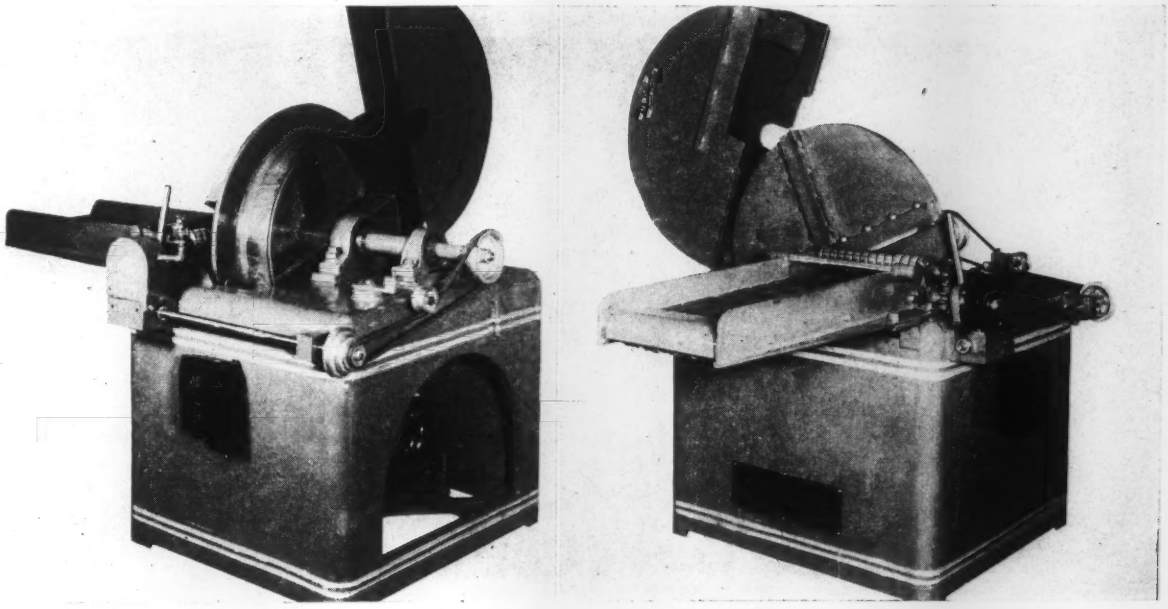
Protection against damage to the lift mechanism from head-on platform shock loads is assured by unique design of the platform linkage, above. If rammed at any time, the platform swings up and back on the suspension links to a solid stop against a heavy cast housing. The lift mechanism remains coupled, but no shock is transmitted to the screw because of the floating link.

Powered by storage batteries or alternatively by a gas-electric power plant, individual drive motors of the new truck are specially built to withstand 350 per cent overload for 30 minutes at not over 65 degrees temperature rise. The traction drive motor is capable of absorbing 1000 per cent of its normal ampere rating for five minutes without permanent damage.

Shredder Disk Fluffs Paper Excelsior

BLOWER action of high-speed cutter blades on the Mitts and Merrill Air-Fluff paper shredder, left, prepares the paper cuttings for optimum packing and insulating qualities by thoroughly fluffing them as ejected from the machine.

Welded steel construction is used throughout, including the blade disk, top, left, next page, which has an integral pulley rim adjacent to the main shaft bearing. Driven by flat belt from a 3-hp motor spring-



mounted in the base of the machine, the disk assembly rotates in pillow-block antifriction bearing assemblies.

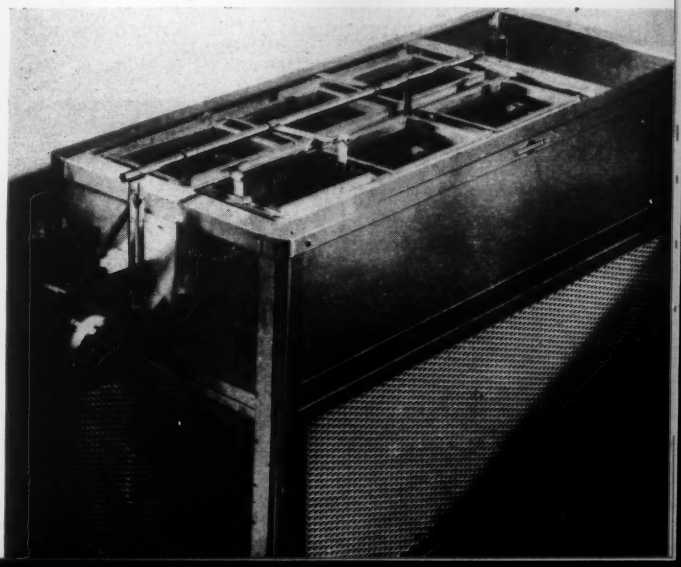
Waste paper, roll paper or cellophane roll stock is fed into the machine by a multiple-belt feed conveyor table, above, right, driven from the cutter spindle through a combination V-belt jackshaft and worm gear drive. Traction to pull the paper onto the stationary cutting blade is provided by a spring-tensioned pressure roll hinged to the conveyor sides. The roll is geared to the conveyor table drive pulley in one-to-one ratio through deep-toothed pinions which maintain engagement continuously although pinion center distance varies in accordance with thickness of the paper stock.

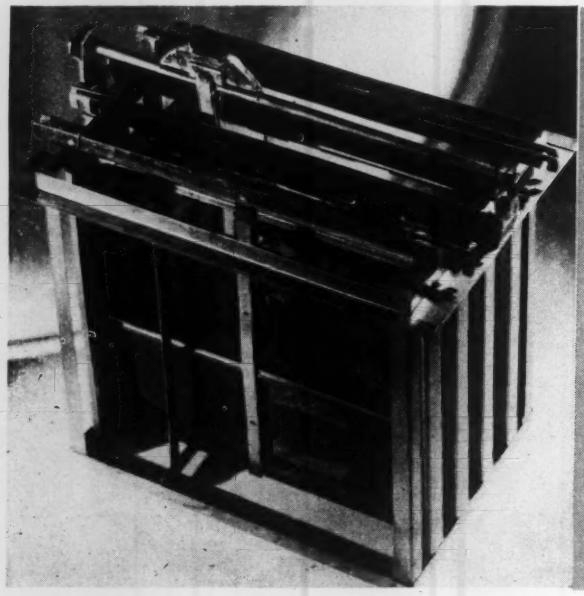
A simple yoke operated clutch on the conveyor drive shaft enables disengagement of the feed by permitting the worm gear to idle on its shaft while the spindle is in motion. Rate of paper feed is variable to produce $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, or $\frac{3}{8}$ wide excelsior by changing the jackshaft belt position on the stepped pulleys. When setup for producing the $\frac{3}{8}$ size, the machine will shred up to 1800 lb of newspaper or magazines per hour.

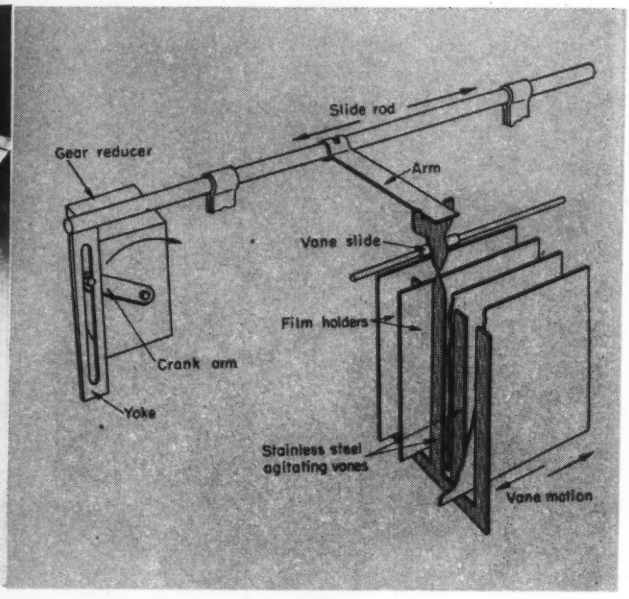
Stainless Steel Improves Developer Control

THREE important requirements in processing color film—complete protection against solution contamination from metal corrosion, uniform solution agitation, and close temperature control of the solution—are successfully met in a new machine, right, (a cover normally houses the drive arrangement), developed and patented by the Newman-Schmidt studios.

External parts of the machine are standard 18-8 stainless steel, and stainless 317 containing molybdenum for extra protection against corrosion is used for all parts exposed to the developer solution. Heart of the processor is the spotwelded film cage, top, next page, which has a built-in "inverted rake" agitator. V-belt driven by a 1/6-hp motor, a Boston gear reducer provides crank motion to reciprocate a slide rod which is coupled by reach arms to sliding heads from which the agitators are suspended. Open construc-







tion of the slide heads permits the arms to be disengaged easily and swung out of the way for removal or interchange of film cages without stopping the machine. Continuous operation thus made possible enables processing up to 600 films, 4 by 5 inches, or their equivalent, in an 8-hour day.

The main tank section is divided into two compartments. Tap water is circulated through the smaller or end compartment for final washing. Noncirculating water in the larger section containing six watertight immersed solution tanks is thermostatically controlled by refrigeration to keep the developing solutions at constant temperature. Heat is removed from the temperature-control fluid through Freon refrigerated coils connected to a Copeland ¼-hp compressor. Walls of the heat exchanger tank are shielded by a two-inch layer of insulation to minimize condensation and to assist in stabilizing the temperature.

Spring Motor Drives Tape Recorder

WEIGHING only 11 lb, the fully portable Reporter tape recorder, below, is powered through a crank-wound double-spring motor and miniature dry-cell batteries. Recording time available through one winding is 8 minutes, which is equivalent to 300 feet or a one-half spool of tape recorded at a speed of 7½ inches per second.

Only three electronic tubes are employed in the recorder and a single three-position switch controls the power circuit. Conventional features such as high-speed rewind, automatic erasure, etc., have been omitted to minimize weight. Normally, recordings are played back on line-powered recorders with regular playback heads. On-the-spot playback for checking is possible by manually rewinding the tape.

Provided with a shoulder strap for convenient handling, the recorder case measures 14 inches by 7½ inches by 6 inches and has storage space in the motor compartment for two extra tape reels. An observation window is provided in the hinged lid of the case for checking reel speed and tape supply.

Built by Wirek Electronics Ltd., battery cost to operate the recorder is said to be as low as 2 to 3 cents per full 16-minute spool.

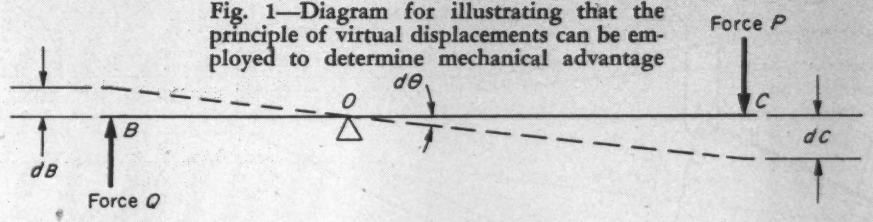


Fig. 1—Diagram for illustrating that the principle of virtual displacements can be employed to determine mechanical advantage

Determining Mechanical Advantage with VELOCITY POLYGON

By R. T. Hinkle
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MECHANICAL advantage of a mechanism can be determined by several methods. With a simple lever, *Fig.* 1, if a force P is applied at C, the mechanical advantage is CO/BO and the ratio of the forces is $CO/BO = Q/P$.

The mechanical advantage can also be determined by the principle of virtual displacements. If the lever rotates through an angle $d\theta$, the displacement of C is $dC = (OC)d\theta$ and the displacement of B is $dB = (OB)d\theta$.
Then

$$\frac{dC}{dB} = \frac{(OC)d\theta}{(OB)d\theta} = \frac{OC}{OB} = \frac{Q}{P}$$

When the bar moves through the angle $d\theta$ it has an angular velocity ω which may approach zero. The linear velocity of point C is $V_C = (OC)\omega$ and the linear velocity of point B is $V_B = (OB)\omega$. Then

$$\frac{V_C}{V_B} = \frac{(OC)\omega}{(OB)\omega} = \frac{OC}{DB} = \frac{Q}{P}$$

This demonstration shows that instantaneous velocities can be considered to represent virtual displacements drawn to a large scale. Since a ratio is to be obtained, the scale does not enter into the calculations and does not have to be considered.

This method can be further demonstrated by its application to the toggle pliers shown in *Fig.* 2. From the skeleton linkage shown on the pliers, the velocity polygon is first constructed. It can be started from any convenient point. The instantaneous velocity of Q is perpendicular to DO_1. A magnitude for this velocity is arbitrarily chosen and laid off in its proper direction as od in *Fig.* 3.

The diagram is completed in the usual manner. That is, in *Fig.* 3, oq takes the direction of Q in *Fig.* 2, dq is drawn perpendicular to oq. Then c is fixed by the intersection of a line through o, perpendicular to O_1C, and a line through d, perpendicular to DC. Similarly, b is established from c and o, a from b and c. The instantaneous velocity of P is oa from which its vertical component op and horizontal component pa can be constructed.

In *Fig.* 3 velocities can be considered to represent virtual displacements to a large scale. Work is the product of force and displacement, but only the component of force that acts in the direction of the displacement does work. Or, work is the product of the

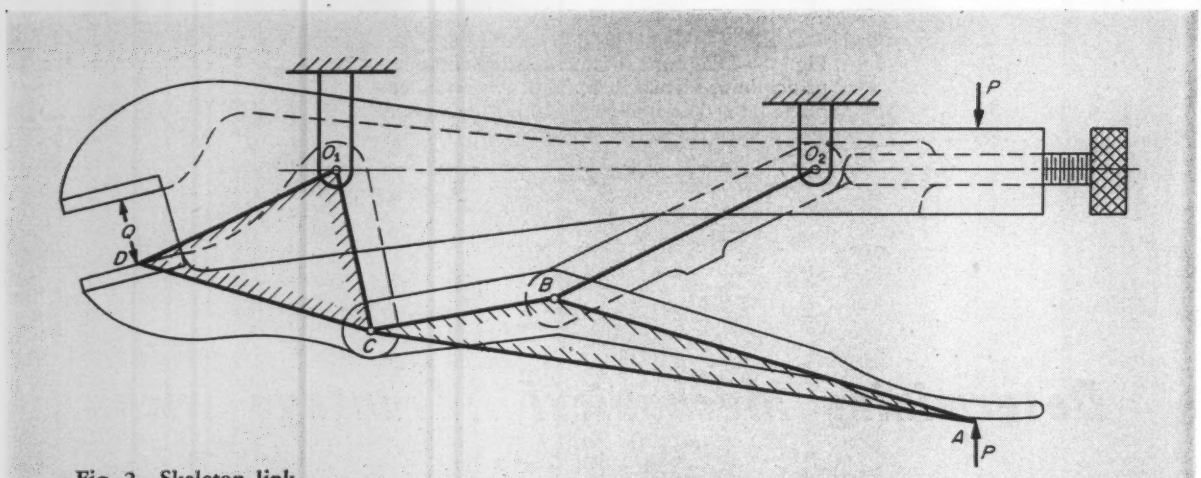

Fig. 2—Skeleton linkage for toggle pliers. Mechanical advantage, the ratio of force Q to force P, is determined by the velocity polygon of *Fig.* 3

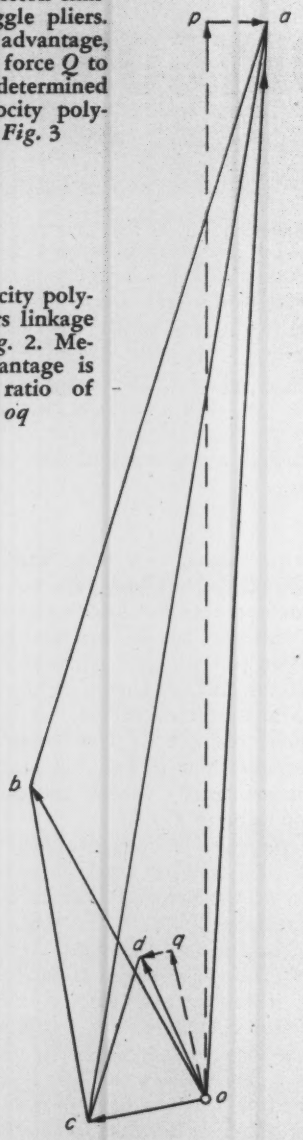

Fig. 3—Velocity polygon for pliers linkage shown in *Fig.* 2. Mechanical advantage is simply the ratio of *op* to *oq*

force and the component of displacement that is in the direction of the force.

At *A* in *Fig.* 2, force *P* is applied in a vertical direction; hence, it does work along *op*, the vertical component of the virtual displacement *oa*. The component of displacement *pa* is perpendicular to the force and no work is done along this displacement. Similarly, at *D* work is done along the component *oq*, that is, perpendicular to the jaw. The work at *A* must equal that at *D*. Then, $P(op) = Q(oq)$, or

$$\frac{op}{oq} = \frac{Q}{P} = \text{Mechanical advantage}$$

If the mechanical advantage is not the desired value, a study of *Fig.* 3 will indicate which links to alter to obtain the required mechanical advantage. If the shape of the handle is altered so that force *P* is applied in the direction of the displacement *op*, the mechanical advantage would be greater. In this case, however, *op* and *oa* are nearly equal; consequently, little would be gained.

The theory of virtual displacements is based on infinitesimal displacements. In practice the forces are large, and because of the elasticity of materials, the displacements are small but measurable. If the piece being clamped in the jaws is round, the displacement component *dq* would cause a slight rolling of the piece. If the piece is flat, the displacement component *dq* represents sliding or shear distortion of the piece. In this case, work is done and the mechanical advantage is less than that indicated by the foregoing analysis. In some types of clamping devices this action might be undesirable.

It is often necessary to determine the mechanical advantage of mechanisms in motion. The outlined method can of course be used in these cases. The pliers were selected as an example in this discussion to show that a problem in statics can be solved with a velocity polygon. The method is not only rapid but it reveals conditions that are not usually apparent in the conventional static force analysis.

QUALITY CONTROL METHODS

Their Use In Design

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Production under control brings important new freedom to design. Real tolerance limits become known and practical limits can be set with assurance. Design under control calls for measurable results in production and, hence, full understanding of gaging and inspection methods by the designer

Part 2–Production Under Control

Fig. 8—All important dimensions of a part must be checked for measurability because control stems from measured results

THERE are certain things a designer should consider about the production phase of manufacturing as they relate to the producibility of his ideas drawn as lines and marked with numbers and special notes. This and the following part of this series will take up some of these important factors.

In the preceding article the definition of statistical quality control was carried through basic principles to a brief description of the main tools. Control charts and sampling plans filled that bill.

In designing for production, you do expect that your work can be produced. And to add a thought—produced under control. It is, or should be, always clear that the parts you design must be ones that can be manufactured and that production should be as economical as possible. The significant new words *under control* mean that parts in quantity can be kept readily within the tolerance limits selected. You might properly say that is someone else's job. The tools and the type of operators picked for the work should be able to hold these tolerances. You also have a right to hope the workmen will use common sense and will be conscientious and experienced. But that is only one kind of control.

In contrast, the use of the scientific method called statistical control will give far better production results with less leaning upon hope. A designer who can plan on his ideas being carried out in this manner

actually works with more freedom in important respects. He can have more confidence about the ability of the shop to work within given tolerances through the virtual elimination of the human element. And, of equal importance in design, he will have the right to accumulate tolerances in a new, but most attractive, and useful way.

Structural Vs. Mating Requirements: Each characteristic of a design has a primary function. A dimension, a hardness, a finish, or any other characteristic either has a structural or a mating purpose. The designation *structural* is used to indicate that a particular characteristic of a part must be held within a given tolerance to preclude failure. Examples of structural requirements are wall thickness, hardnes of material perhaps as related to tensile strength, a stress-relieving radius, requirements as to grain flow, or freedom from magnetic particle indications greater than a given length or in a given direction. A *mating* or *nonstructural* characteristic is one which, if beyond maximum limits, may result in improper functioning or inabiilty even to assemble parts properly.

Electrical, chemical, hydraulic, and other functions can be similarly handled. As in the mechanical case, a more important feature of each characteristic acts alone or in combination with a mating one.

Classification of specifications under these two general headings will assist greatly in determining not only how to design for production under control but also in how to inspect the product to confirm that it was produced that way, *Fig.* 8.

The foregoing implies that parts that do not meet tolerances will be unsatisfactory. As a designer you would like always to be able to call for such real limits but: (1) you seldom know what the real limits are, even if a rather sharp dividing line exists, and; (2) you feel there are production methods that can hold to limits well within a band that does not have to extend into the zone of uncertainty. Hence, it is not difficult to understand the shop man's feeling that there are few practical designers.

These articles will cover statistical methods for doing a better job with the second item, and for developing more knowledge about the real capability of available processes. In some cases, however, it is worth the effort to go after the first problem of the real limits. Tests for this purpose become valid when considerations are given to other statistical techniques.*

In the first part of this series, *Fig.* 2 showed the results of stable variation usual with an undisturbed process. Values were distributed to fill out into a normal curve. It will be recalled that such relative frequencies come from variables of equal strength joining at whatever values they take by chance. In no real process are their strengths all equal. So, the more variables the process has, the better, because the results strike closer to this theoretical case. There are so many values that the effects of the few rather stronger variables are pretty well averaged out by the main effect of the much larger number of nearly equal strength. The effects of the rather weak ones become negligible.

Typical understanding of the "rule" set down by the drawing to the shop, as to how parts could be made within limits, is illustrated in *Fig.* 9. If pressed the designer might also admit that any pattern or distribution would be acceptable—just so long as all the pieces came somewhere within the tolerance.

Actually, of course, the rectangular patterns of *Fig.* 9 are practically impossible to obtain from a production process. But, without control charts you do not always get the well-centered normal distributions of *Fig.* 10. Quite often, when you do get a normal distribution, it is lying closer to the high limit for external dimensions, or closer to the low limit for internal ones. The machine operator usually likes to leave material on a part to allow stock for rework if trouble develops. In many such cases, without control charts, an operator will work too close to the limit and by so doing get more rework for himself by having the high end of the distribution extend beyond the limit while there is plenty of unused tolerance at the low end.

* Cochran and Cox—*Experimental Designs*, John Wiley & Sons, Inc., 1950.

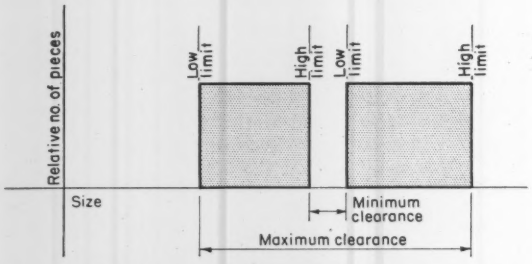


Fig. 9—Typical drawings indicate that parts can be made to tolerances that fall equally into any given point within the total range

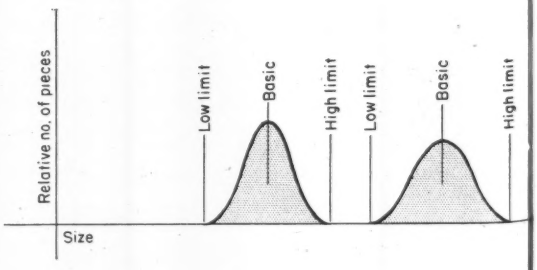


Fig. 10—Tolerance patterns such as these, or narrower ones of the same shape, can be maintained if production is under control

It is not simple to find a good reason to explain the paradox why, rather often, just the opposite is found taking place; shop men actually removing too much stock consistently. Perhaps it is more evidence of what can happen when the built-in variability is not known. Operators have to overcome feeling that one piece is representative of others at the same setting. Then, of course, there are other cases where the distribution does not stay fixed because of continual adjustments to the machine, changing tools, etc. Almost any imaginable pattern can be the result. Working with control charts the operator can keep the process under statistical control. This means that he can keep the distribution fixed in a centered position and keep it near normal. Against this background the designer can do some predicting about the basic size and variation that will be met.

When the specification is a structural one the designer would like to count upon the variation as following a normal pattern, like one of those shown in *Fig.* 10. Let us say a wall thickness is specified on a part machined from a forging. One side of the wall is machined but the other remains a forged finish. The minimum wall thickness needed comes from engineering considerations; the problem of the maximum allowable wall thickness that should be specified can be helped by SQC. It may be desirable to take into account the weight of the part, the cost of more accurately aligning the forged contour with the machined surfaces, procuring more uniform forgings, and obtaining smaller machining variation. These characteristics are all measurable ones. Data about them can be had from samples of former production results on the same or similar parts, or from pilot-line production.

Relation Between Practical and Natural Tolerance: The economical way to find the position and width of the inherent frequency distribution of the machining, the forging, and the alignment, is to use Shewhart $\overline{X}$ and R charts. The steps will be covered in Part 7 of this series, "Determining Practical Tolerances." How process capabilities, expressed as six standard deviations, are wilfully broadened to a spread of eight standard deviations will be covered. This provides a practical tolerance that can be held easily among many setups and with the new tools or dies that will have to be used from time to time.

The control chart serves a second but equally important job, in addition to helping determine tolerances. It permits subsequent production to stay within these limits. Instead of a costly tussle between the designer's initial tolerances and efforts to try to meet them in production, the operator will settle the question on paper early. His statistical chart data show whether this particular job is safely running as was expected. The chart almost always reveals a change before any scrap or rework occurs.

Hardness is another structural requirement handled in much the same way, with an $\overline{X}$ and R chart. Here, actual preliminary results on different furnaces, several analyses, or heat treatments can be balanced against the wanted design features. Control chart data again make this usually costly task a practical one. Reliable information stems from rather meager data or even from past data of similar materials.

Design of castings, with regard to the gating that will be necessary to keep porosity to an acceptable minimum, can be studied, *Fig.* 11. Plots of the results from a few X-rays or sectioned castings are

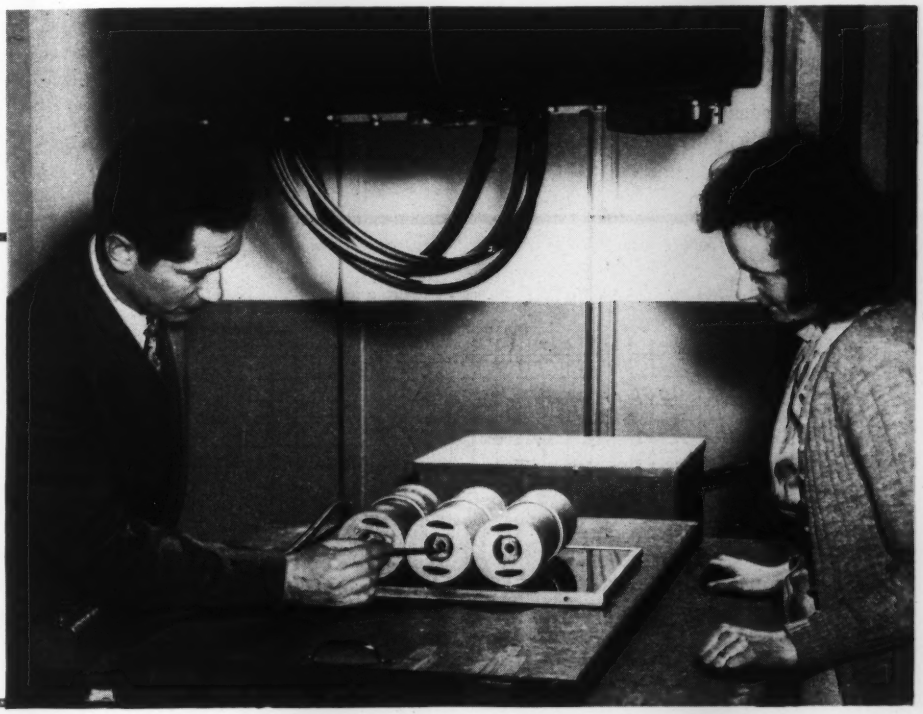


Fig. 11—Effect of different gating methods on casting soundness can be determined by X-ray porosity counts

made on a *c* chart. A comparison among three different gating methods stands out clearly on the separate *c* charts of *Fig.* 12. The effect on porosity here is significant.

Magnetic-particle inspection data can help in determining a die design that will not lead to laps in the material. This statistical tool is a *p* chart for fraction defective. These aids do not just show results that would be obvious anyway. The charting dictates the correct amount of data and helps prevent costly errors in decisions.

Assembly Situations: Mating characteristics involve more than one distribution. The simple case shown in *Fig.* 10 was illustrative of two parts to be assembled. Because there are so few parts lying near each of the tolerance limits, it is unlikely that parts at these extremes would be picked by chance to make an assembly. To take advantage of this case, effective variation of the clearances in chance assemblies should be calculated. These assembly limits will not be as wide as those figured by subtracting the extremes of the mating part tolerances. Again in Part 7, "Determining Practical Tolerances," this matter will be gone into further.

As mentioned previously, practical experience with SQC has shown that including 99.7 per cent of the output can be considered as correspoding to all the output. The scheme of designing mating tolerances so that 99.7 per cent of the assemblies fall within the desired fit requirements is an example of the extension of this type of practical thinking.

Designing for production under control with the aid of SQC will be a rather amazing experience. It is surprising to find that many processes can run at natural tolerance very much less than the tooling experts ever would admit. In all fairness to the expert, however, it is necessary to explain that these amazing results are only possible when $\overline{X}$ and R charts are used. By actually seeing what is happening, an operator usually puts less extra variation into his work. He sees when to leave things alone. Only in a few cases the tolerances tooling experts claimed could be held were impossible; and the charts clearly showed it.

Tables listing the natural tolerances or process capabilities of equipment in any shop can be of great value to design engineers as well as tool engineers who have the task of assigning jobs to that shop. In Part 6, processes and natural tolerances will be dealt with in detail to assist in this respect.

Designing For Control: An $\overline{X}$ and R chart is the tool that helps keep results centered and normally distributed. It also furnishes the data needed concerning the built-in variation of the process. The calling out on a drawing of the specific dimensions or other characteristics that should be controlled by such a Shewhart chart then becomes a logical step. Industry is fast approaching full acceptance of the control chart as a design requirement. After all, it has the happy ability to get the "most" out of a process by cutting variation to a practical "least."

From a list of natural tolerances one is selected that came from the process to be used for the particular operation planned. This is corrected, if necessary, for the different size of work and/or different material. These amounts also come from past control chart records from the shop. This expected natural tolerance is then increased by one-third—going from six to eight standard deviations to allow for setup differences. However, a special notation should be used, to be described in a later article, on the drawing to require the use of the control chart when operating to this tolerance.

As has been pointed out, under the normal curve, 67 per cent of the output falls between plus and minus one standard deviation of the center or nominal value. The central two-thirds of the spread holds 95 per cent and 99.7 per cent falls into plus and

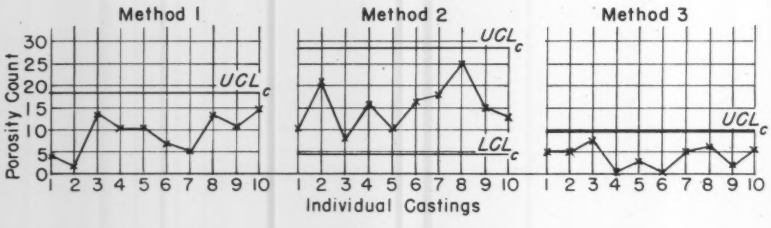
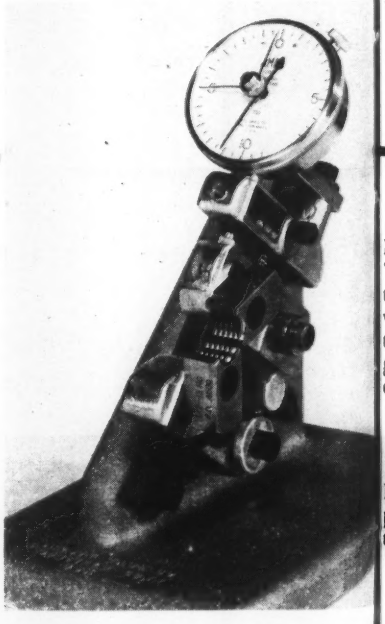


Fig. 12—Above—These *c* charts show that the improvement resulting from gating method 3 is more than can be ascribed to chance—it is statistically significant



minus three standard deviations. Letting the lesser natural tolerance float in an eight-sigma spread alters these ratios only slightly. At the very least 62 per cent of the output can be expected to come within the middle third of the tolerance placed on the drawing. The other two minimum figures will still be 95 per cent and of course practically all the output.

Most plants have their designs checked in some manner for producibility. Of course, there must be a way to fabricate the product; but the time to find that out is before the drawing leaves the design department. At this point, however, a step must be added: each important requirement s h o u l d be checked for measurability. Control stems from *measured* results hitting a control chart as tracer bullets, so gages and inspection methods have to be studied by the designer.* Dimensions must be struck from measurable locations rather than from centerlines that cannot be readily fixed by a practical gage. Indication on the drawing of the physical surfaces to be used as preferred locations for gaging will do two important things: (1) Usually eliminate many man-hours of controversial discussion among production, inspection and tooling personnel; (2) provide assurance that the controlled product will be functionally correct.

Gage types that can be used are important in making control possible. An $\overline{X}$ and R chart records measurements and is known as a control chart for variables. So a "variables" type of gage, not an "attribute" type, is needed, *Fig.* 13. A micrometer or dial indicator type of comparator can do the job. Go and not-go, receiver type and such gages will *not* give readings that can be plotted.

Besides actual measurement, success in plotting is dependent upon readings significant in terms of the inherent variation of the process. A steel scale, of course, practically never can be used. Today, sometimes a micrometer is too coarse. A good rule to follow is to be able to divide the natural tolerance into a minimum of seven intervals. Keep this in mind for the meters needed for timing, speed, electrical and hydraulic measurements, for tensile strengths, for hardness readings, and other necessary measurements.

While thinking about how a new design can be made and measured for control of production, consider another factor. Inspectors will be ever grateful to designers who specify the correct and practical type of measurements wanted. How many designers have been guilty of anything like the following on drawings?

1. Calling out a Brinell hardness range on a part that is too thin to take such an impression, or has finished, working surfaces all over that should not be marked with a large ball indenter? Requiring a conversion to one of the Rockwell scales or to a Vickers reading? (Most conversion tables do not agree.) Or simply specifying ultimate tensile strength and leaving a real controversy to the shop? Be specific and practical in hardness specifications. Get figures on how close certain scales can be read. Will they fit the one-seventh rule?
2. Placing tolerances on two or more dimensions related in such a way that one or more locates the spot from which the other is read? Only the latter should carry a product tolerance. The first ones mentioned are locating, reference or "gage" dimensions.
3. Disregarding the dimensional changes, in close-tolerance locations, brought on by finishes or treatments? Plating, anodizing, induction hardening and such other treatments do have dimensional effects. Make it clear what tolerances you want both before and after treatment, when tolerances are tight.

The drawing shown in *Fig.* 14 exemplifies good practice in the foregoing respects. Hardness values in Brinell of the AMS specification have been properly converted to the Rockwell B scale, the angle properly has a tolerance, locating dimensions are specified as "gage" without tolerance, and the 0.0002 to 0.0003-inch buildup from anodizing is recognized as having four times this effect on thread pitch diameter.

* C. W. Kennedy—*Inspection and Gaging*, The Industrial Press, 1951.

Fig. 13—Left—A typical "variable" type gage for external threads permits individual measurements as contrasted to "go" and "not-go" gages which merely accept or reject within a given tolerance range

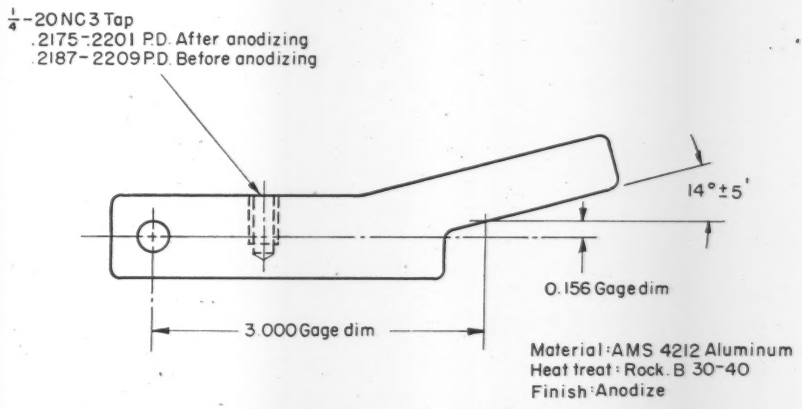


Fig. 14 — Right — Typical part drawing which fulfills the basic requirements for measured control

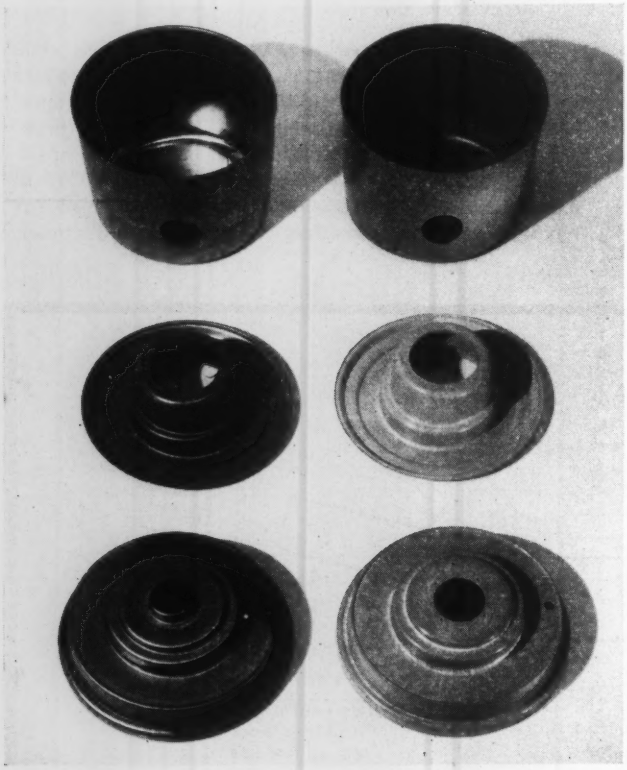
Redesign for Plastics

Judicious use and selection of plastics in design can afford important cost and weight savings as well as improved styling and service

AS A RESULT of redesign aimed at improved appearance and function and reduced cost, prompted partly by acute shortages of critical metals, the Lewyt Corporation has converted sixteen vacuum cleaner parts formerly made of metal or rubber to plastics. Many of the new parts, which are shown in the accompanying illustrations*, have resulted in dramatic savings in cost. Because of these cost savings and important savings in weight, approximately half of the new plastics components can be expected to be retained in the cleaner design regardless of future availability of metals or rubber.

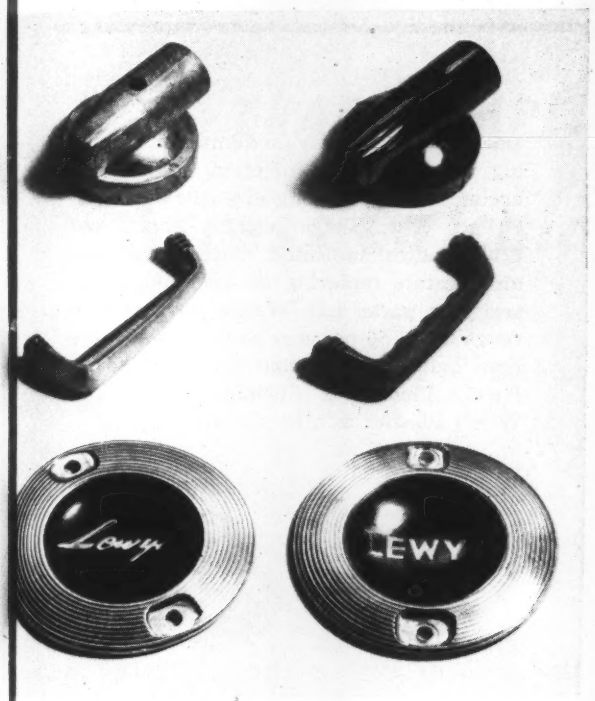
Four acetate parts, two ethyl cellulose parts, and a vinyl bumper were incorporated in the original design of the cleaner and were retained when the cleaner was newly styled. The performance of all of the original plastics parts was highly satisfactory. Tests on the new plastics components made an equally good showing. With the possible exception of the polyester parts in the tank and two motor support rings made of acetate and the styrene nameplate, the new plastics elements are excellent examples of the real dollars-and-cents economies afforded by redesign for producibility.

* Data and illustrations, courtesy Hercules Powder Co.



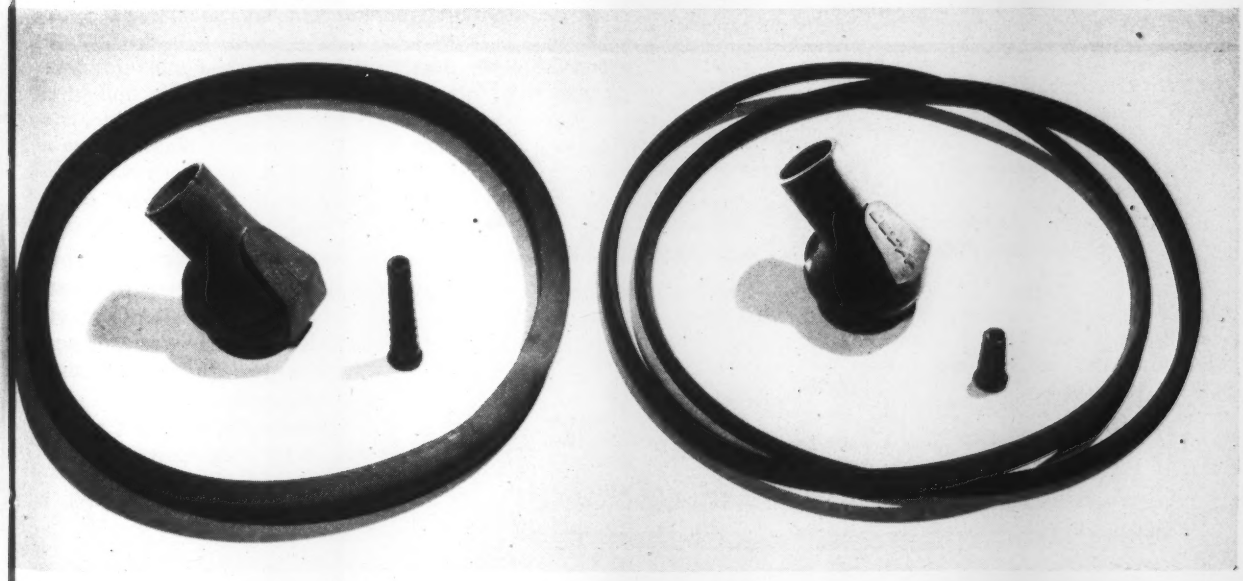
Important reductions in unit weight were effected when reinforced polyester plastics were used in place of steel for the dust bowl, middle and inner shells of the cleaner. By using plastics for this part ot the job, Lewyt actually saves well over eight pounds of steel for each set of polyester parts made. Actual weight of the metal parts was approximately six pounds; the balance being consumed in fabrication. Total weight of all three parts in plastics is only 25 ounces. Polyester parts, however, cost almost twice as much. Plastics may lose out to metal again in this part of the assembly should steel become readily available. However, if the price of polyester parts, as is expected, becomes more competitive, production may remain permanently in a glass mat reinforced polyester. Molded by Molded Resin Fiber Co. and Auburn Button Works Inc.

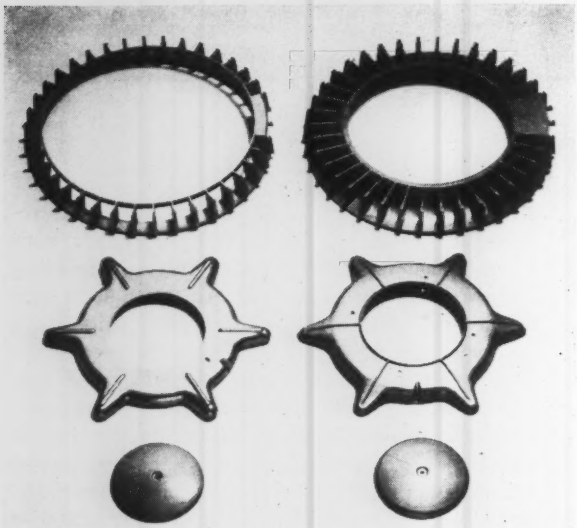
DESIGN



Phenolic spray gun body, shown top right, replaces a die-cast aluminum alloy part, left, with a weight saving of 10 per cent and a cost saving of approximately 25 per cent. Acetate handle with molded-in metal core, center right, resulted in a weight saving of 60 per cent over die-cast aluminum part previously used, left. Cost of new handle is only half that of original. Nameplate, formerly an aluminum stamping, bottom left, is now molded with styrene plastic, is better looking, but doubled the cost of this part of the assembly. Spray gun body molded by Norton Laboratories Inc., handle and nameplate by Hardy Plastics & Chemical Corp.

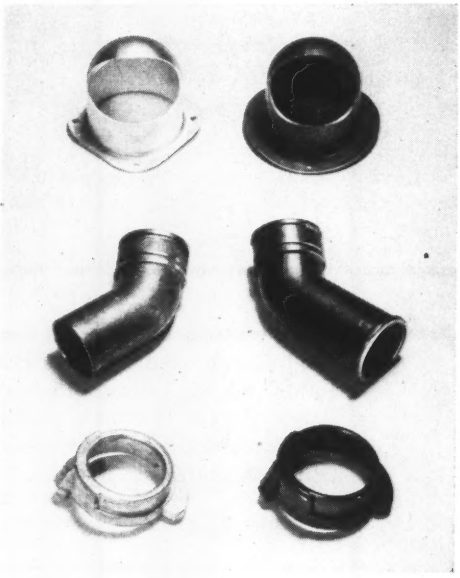
Three parts in the vacuum cleaner formerly made of rubber are now made of vinyl plastic, resulting in a better color and finish. These include the bumper gasket, dusting brush holder, and cord strain grommet, shown right. In this instance, the switch-over to plastics increased costs from 16 to 64 per cent, but the more satisfactory appearance and performance and incorporation of identification with plastics may result in continued use even when rubber supplies ease. Molded by Welch Plastics & Mfg. Co. Inc.

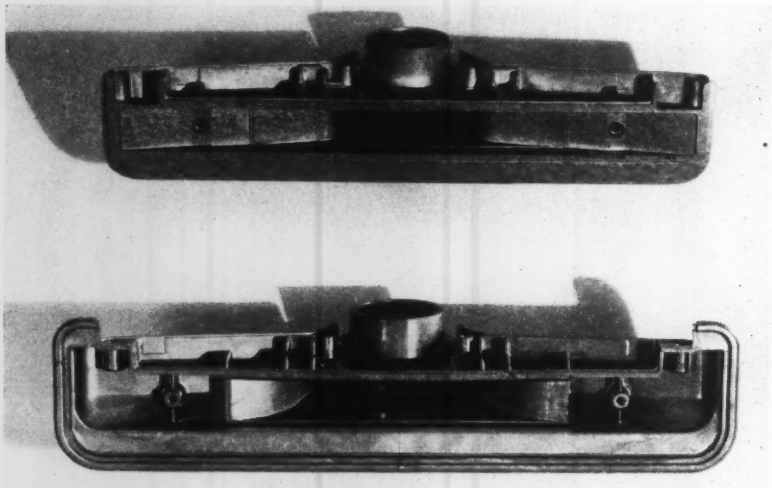




Air diffuser, top left, of die-cast aluminum alloy is now molded with cellulose acetate, top right, resulting in a weight saving of 50 per cent and 11 per cent reduction in material cost. Motor support ring and motor support disk, center and bottom, are now molded of acetate, right, replacing parts previously made of steel. Savings in cost ran 25 per cent or more. Molded by Hardy Plastics & Chemical Corp.

Inlet fitting, formerly an aluminum stamping, top left, is now injection molded with acetate, right, resulting in a cost saving of 20 per cent. Elbow nozzle, center, and brush control indicator, bottom right, are also acetate replacing die-cast aluminum and zinc parts, left. Weight savings here range up to 50 per cent and cost was more than halved in each instance. Molded by Hardy Plastics & Chemical Corp., and Welch Plastics & Mfg. Co. Inc.





Acetate rug nozzle, bottom, which replaced the heavier aluminum alloy part with a weight saving of 50 per cent. Cost of plastic part was 36 per cent less than aluminum die casting. Molded by Hardy Plastics & Chemical Corp.

CHART SIMPLIFIES
Stress Calculations

By Harold M. Durham
Pittsburgh, Pa.

A USEFUL chart for quick resolution of frequently occurring stress problems is shown in *Fig.* 1. Among the problems readily solved are:

1. Bending and torsion by the maximum stress theory
2. Bending and torsion by the maximum strain theory
3. Bending and torsion by the maximum strain energy theory
4. Bending and torsion by the maximum shear theory
5. Factors of safety and stress ratios
6. Principal stresses and resulting shear
7. Tension and resulting shear.

For finding the principal stresses produced by bending and torsional moments, the individual stresses are first found, then their ratio is calculated, and finally they are combined by use of the chart. This method is in lieu of finding equivalent moments. The chart eliminates certain calculations and reduces others to a nomographic procedure. The domain of application of the various equations is discussed in most text books on strength of materials. The examples on page 181 illustrate applications of the nomogram to various problems.

Equations: For combined bending and shearing stresses, four theories are in use. In the following equations expressing those theories, the nomenclature is as follows:

S_t = Nominal stress in tension
S_s = Nominal stress in shear
S_{et} = Equivalent stress in tension
S_{es} = Equivalent stress in shear
$R = S_t/S_s$

Maximum Stress (Rankin)

$$S_{et} = \frac{S_t}{2} \pm \sqrt{\frac{S_t^2}{4} + S_s^2}$$

$$= \frac{S_t}{2} \pm S_s \sqrt{\frac{R^2}{4} + 1}$$

Maximum Strain (St. Venant)

$$S_{et} = 0.35\,S_t \pm 1.30 \sqrt{\frac{S_t^2}{4} + S_s^2}$$

$$= 0.35\,S_t \pm 1.30\,S_s \sqrt{\frac{R^2}{4} + 1}$$

Maximum Strain Energy (Hencky-VonMises)

$$S_{et} = \sqrt{S_t^2 + 3\,S_s^2}$$

$$= S_s \sqrt{R^2 + 3}$$

Maximum Shear (Guest)

$$S_{es} = \sqrt{\frac{S_t^2}{4} + S_s^2}$$

$$= S_s \sqrt{\frac{R^2}{4} + 1}$$

Chart Scales: In the nomogram, *Fig.* 1, scales *a*, *b* and *c* have constant values, while scales *d*, *e* and *f* are to be multiplied by the same factor simultaneously. For instance, when scale *d* is multiplied by 1000, scales *e* and *f* also have the multiplier 1000. Occasionally values exceed the range of scale *e*. In such cases, a larger multiplier such as 2000 or higher may be used.

Data Sheet

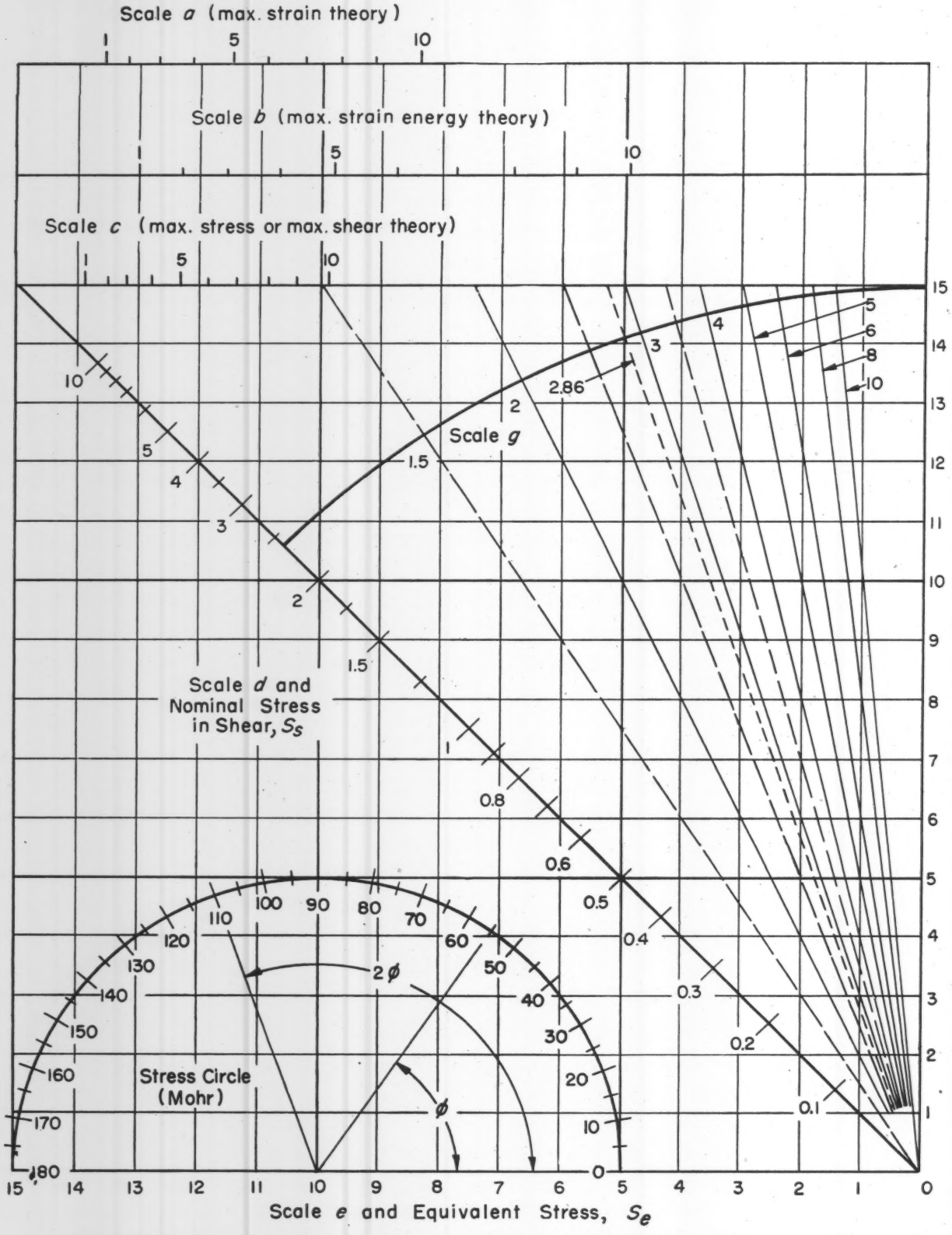
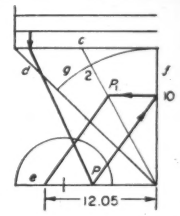
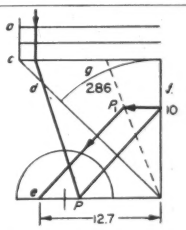

Scale a (max. strain theory)
Scale b (max. strain energy theory)
Scale c (max. stress or max. shear theory)
Scale g
Scale d and Nominal Stress in Shear, S_s
Stress Circle (Mohr)
2φ
φ
Scale e and Equivalent Stress, S_e

Fig. 1—Nomogram for solving stress problems typified by the examples given on facing page 181

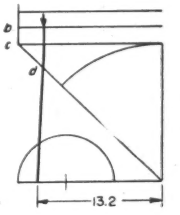
Stress Calculations



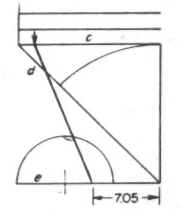
1. *Given:* Nominal bending stress of 10,000 psi and nominal shear of 5000 psi. *Find:* Equivalent tensile stress with the maximum stress theory. *Scales: c, d, e, f; g* = 2. $R = 10{,}000/5000 = 2$. *Solution:* Enter *c* at 2, intersect 5 on *d*, extend to *e* (point *P*). Enter *f* at 10 and locate point P_1 on g = 2. Draw parallel to $P-10$ through P_1 cutting *e* at 12.05. Then, $S_{et} = 12.05\ (1000) = 12{,}050$ psi.



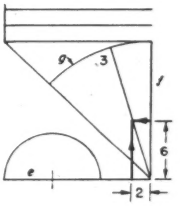
2. *Given:* Nominal bending stress of 10,000 psi and nominal shear of 5000 psi. *Find:* Equivalent tensile stress with the maximum strain theory. *Scales: a, c, d, e, f; g* = 2.86. *R* = 2. *Solution:* Enter *a* at 2, drop vertical to *c*, intersect 5 on *d*, extend to *e* (point *P*). Enter *f* at 10 and locate point P_1 on *g* = 2.86. Draw parallel to $P-10$ through P_1 cutting *e* at 12.7. Then, $S_{et} = 12.7\ (1000) = 12{,}700$ psi.



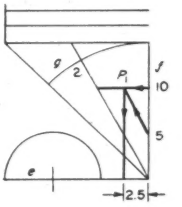
3. *Given:* Nominal bending stress of 10,000 psi and nominal shear of 5000 psi. *Find:* Equivalent tensile stress with the maximum strain energy theory. *Scales: b, c, d, e.* *R* = 2. *Solution:* Enter *b* at 2, drop vertical to *c*, intersect 5 on *d* and extend to *e*. Read 13.2. Then, $S_{et} = 13.2\ (1000) = 13{,}200$ psi.



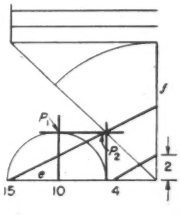
4. *Given:* Nominal bending stress of 10,000 psi and nominal shear of 5000 psi. *Find:* Equivalent shear stress with the maximum shear theory. *Scales: c, d, e.* *R* = 2. *Solution:* Enter *c* at 2, through 5 on *d* draw diagonal to *e*. Read 7.05 on *e*. Then, $S_{es} = 7.05\ (1000) = 7050$ psi.



5. *Given:* Yield point = 60,000 psi, working stress = 20,000 psi. *Find:* Factor of safety. *Scales: e, f, g.* *Solution:* Enter *f* at 6, enter *e* at 2. Read 3 on *g*.



6. *Given:* The shearing stress equals the difference of the principal stresses divided by 2; $S_1 = 10{,}000$ psi, $S_2 = 5000$ psi. *Find:* Shear S_e. *Scales: f, e, g* = 2. *Solution:* Enter *f* at 10 and proceed to *g* = 2. Draw parallel to *g* = 2 through 5 to P_1 and drop vertical to scale *e*. Read 2.5. Then, $S_{es} = 2.5\ (1000) = 2500$ psi.



7. *Given:* A specimen has a uniform tension of 4000 psi. *Find:* Resulting shear on a section at an angle $\phi = 45$ deg to the direction of tension. *Scales: e, f* and Mohr's Circle. *Solution:* On Mohr's Circle at 2 $\phi = 90$ deg, point of maximum shear is P_1. Draw vertical at 5, find intersection P_2 with horizontal projection from P_1. Draw P_2-15, the ratio line of tension on *e* to shear on *f*. From 4 on *e*, project line to scale f parallel to P_2-15. Read 2. Then, $S = 2(1000) = 2000$ psi, the shear stress on a plane at 45 deg to direction of tension.

By John J. Chyle
A. O. Smith Corp.
Milwaukee, Wisconsin

DESIGN ABSTRACTS

Selecting the Correct Welding Process

IN the field of welding technology, a tremendous amount of research investigation has been carried out which has led to a marked improvement in many of the older processes, and has also stimulated the invention of new processes, some of which are less than ten years old. Research and development of welding processes is continuing, and further improvement in existing processes as well as the introduction of new processes is to be expected in the future.

Various welding processes which have been developed can be classified according to the source of heat, application of pressure, or the addition of filler metals. The classification which has been adopted by the American Welding Society is based upon a group of eight distinct processes, and each group is further subdivided so that there are a total of thirty-seven separate welding processes. Each of these thirty-seven welding processes could be further subdivided as to whether they are manual or automatic, and whether alternating or direct current is used. The eight distinct welding groups are as follows in the order of their importance:

1. Arc
2. Resistance
3. Gas
4. Braze
5. Forge
6. Thermit
7. Induction
8. Flow.

Only the most important processes in commercial use today will be considered here. It is therefore obvious that this discussion can only be a guide to help in the selection of the most suitable welding process. Selection must be based on the most economical use of materials and labor. The product to be welded must fulfill engineering design and service requirements and, where several welding processes are applicable, the process resulting in the lowest cost must be used.

The factors in the selection of the most suitable welding process will depend on the following:

1. Engineering design and service requirements of the product
2. Inherent characteristics differentiating the various welding processes
3. Characteristics of the welds made by the various processes
4. Composition of metals to be welded
5. Welded joint design
6. Production rate
7. Power availability.

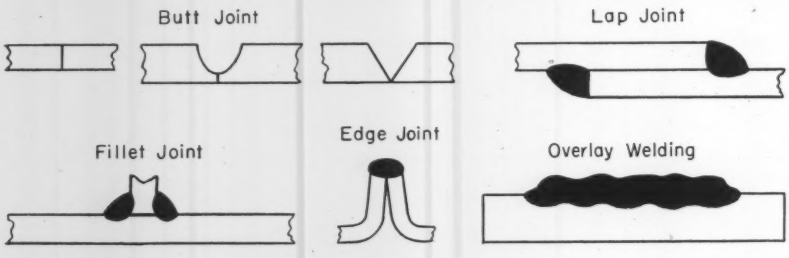


Fig. 1—Basic joints shown here are classified in Table 2 for suitability with the different welding processes

Engineering Requirements: First consideration must be given to the welded product. Before a satisfactory design can be made, it is necessary to know the service requirements of the product—the magnitude and distribution of the loads or stresses to be carried; whether oil or watertightness is involved; operating pressures; what corrosion, if any, will be encountered; the required life of the structure; the appearance requirements, if any; the temperature conditions to which the product will be ex-

posed; and the mechanical properties necessary for successful performance. Only after these service requirements have been given proper consideration and study is it possible to determine the material which can be used in the most economical manner. With the selection of material, it is then possible to consider the other factors before a final selection is made as to the most economical welding process applicable to the product.

At all times the guided decision must be based on the cost of welding, striving for the lowest cost consistent with adequate fulfillment of the service requirements. The decision of what constitutes adequate quality for service requirements is sometimes difficult to determine, and in some cases may require extensive investigation by corrosion testing, proof loading, fatigue testing, etc.

Consideration must be given to:

1. Operating temperatures and pressures
2. Mechanical properties
3. Physical properties
4. Chemical properties
5. Types of loading.

The operating temperatures will determine, to a large extent, the composition of the metal or alloy which will be most suitable and economical for the service requirements. Mechanical properties required in the product must be known so that the welding process which will produce a joint to comply can be selected. It is important to know the tensile strength, the yield strength, and ductility, as expressed by elongation and reduction of area of the parent stock and weld metal. Other mechanical properties such as impact strength, notch toughness and fatigue strength may also be of importance, and consideration for these must be given for both weld and parent material.

With regard to physical properties, it is important to know whether the weld metal must have characteristics similar to those of the parent stock. The physical properties to be considered are:

1. Hardness
2. Electrical conductivity
3. Thermal conductivity
4. Magnetic.

The chemical composition of the weld metal must be given consideration since in some welding processes the chemistry or composition of the weld differs from the parent stock to a large extent. Where corrosion is an important factor, composition of the weld metal is critical and may vary widely, depending upon the welding process that is used.

Inherent Characteristics of the Processes: After the preliminary design has been considered from the standpoint of meeting service conditions, and the material has been selected, further consideration must also be given to the inherent characteristics of the welding process. This factor involves:

1. Source of heating
2. Type of shielding
3. Preparation for welding
4. Addition of filler metal
5. Application of pressure
6. Completion of joint
7. Practical aspects of inspection.

The source of heating characterizes many of the welding processes. Heat from electric power is created by resistance to flow of electric current. This is represented by spot, seam, projection, flash, and upset welding. Heat may also be produced by an electric arc, as represented in the shielded metal-arc process, the atomic-hydrogen process, the inert-gas metal-arc process, and the submerged arc process. Heat may also be created by a discharge of stored electrical energy, as illustrated by the percussion welding process.

A second source of heat may be from the combustion of gases, such as oxygen with acetylene, with hydrogen or with other hydrocarbon gases. The oxyacetylene welding process represents this group.

Forge welding is an example where charcoal, coke or coal is used for heating the metal parts up

Table 1—Recommended Welding Processes for Different Materials*

Material	Welding Process										
	Metal-Arc (shielded)	Submerged-Arc	Atomic Hydrogen	Tungsten Arc (inert gas)	Metal-Arc (inert gas)	Flash	Spot	Gas	Brazing (Furnace)	Brazing (Torch)	Thermit
Steel, low-carbon (SAE 1010, 1020)	R	R	S	S	S	R	R	R	R	S	S
Steel, medium-carbon (SAE 1030, 1050)	R	R	S	S	S	R	R	R	R	S	S
Steel, wrought alloy (SAE 4130, 4340)	R	R	S	S	S	R	R	S	S	NR	S
Steel, stainless (AISI 301-309-316)	R	R	R	R	R	R	R	S	RS	S	NR
Steel, stainless (AISI 405-430)	R	S	S	S	S	S	S	S	S	S	NR
High-Temperature Alloys (19-9DL 16-25-6)	R	S	S	S	S	S	S	S	NR	NR	NR
Iron, gray cast	S	NR	NR	S	NR	NR	NA	R	NR	R	S
Aluminum, Aluminum Alloys	S	NR	S	R	R	S	R	S	R	R	NA
Nickel, Nickel Alloys	R	S	S	R	R	S	R	S	S	R	NR
Copper, Copper Alloys	NR	NR	NR	R	R	S	S	S	S	R	NR
Magnesium, Magnesium Alloys	NA	NA	NR	R	S	NR	S	NR	NR	NR	NA
Silver	NR	NR	R	R	S	S	NR	R	S	R	NR
Gold, Platinum, Iridium	NR	NR	R	R	S	S	S	R	S	R	NR
Titanium, Titanium Alloys	NA	NA	NA	R	NR	S	S	NA	NR	NR	NA
Molybdenum, Tungsten, Uranium, Vanadium, Zirconium	NA	NA	NR	R	NR	S	S	NR	NR	NR	NR

* R = Recommended S = Satisfactory NR = Not Recommended NA = Not Applicable

to a welding temperature. Heat may also be created by a chemical reaction, which is illustrated by thermit welding. In this process the heat generated is caused by the chemical reaction taking place between aluminum powder and iron oxide.

Welding processes may be differentiated by the type of shielding that is used to protect the molten metal from contamination with atmospheric gases. For many welding processes, shielding of the hot weld metal must be adequately effective to preserve the metallurgical quality of the weld. preventing any deleterious action of oxygen and nitrogen in the air combining with the weld metal. The shielding of weld metal may be accomplished by:

1. Gases
2. Liquid flux
3. Solid granular flux.

The protection of the hot metal against contamination is usually accomplished by gas shielding. Inert gases, such as helium and argon, are extremely effective in protecting the molten metal from oxygen and nitrogen in the atmosphere. Reducing gases such as hydrogen and carbon monoxide can also be effectively used to prevent oxidation and nitriding of the molten metal. A good example of the use of reducing gases is the atomic-hydrogen process which is used for welding stainless steel, aluminum, and many other metals where protection against oxygen and nitrogen is extremely important. In the bare metal-arc welding process, no special gas for shielding is used, and molten metal is exposed to the atmosphere.

Another method of shielding is by liquid fluxes. In the oxyacetylene brazing process, the flux which is applied as a solid material is converted to a liquid by the heat of the welding process and this liquid on top of the molten metal shields the metal against contamination from the atmosphere.

Another method of shielding uses solid granular flux material. The process which employs this type of shielding, and is widely used, is submerged-arc welding. In this process the oxygen and nitrogen of the air are excluded by the granular flux surrounding the molten metal. In the arc zone the granular flux becomes a molten blanket covering the hot weld metal and protects it from the oxygen and nitrogen of the air.

Processes also differ according to the method of pressure application. In some processes pressure is an important factor in the welding operation. Flash welding is such a process. Processes which do not require pressure are, in general, the arc welding processes such as the shielded metal-arc, inert-gas metal-arc, and submerged-arc.

All of the resistance welding processes require pressure. The success and quality of the weld will depend largely on the application of the correct amount of pressure at the proper time in the welding cycle. In some processes pressure is applied intermittently, while in others it is applied as a single blow and in still others, the application is of constant duration.

The welding processes differ radically in the addition or omission of filler metal. In some processes the addition of filler metal is made by means of a bare filler wire, as in oxyacetylene and atomic hydrogen processes. The metal is added in rod or wire form to fill a welding groove. In the shielded metal-arc process, the filler wire is a covered metal electrode which is the source of the deposited metal. In other processes, no addition of filler metal is required. The resistance welding processes are of this type, and include spot, seam, and flash welding.

Welding processes may be characterized according to the method of completion of the joint. A welded joint may be completed simultaneously or in a progressive manner. Welding grooves may be completed by depositing weld metal in a number of layers, or the entire weld may be made in one operation. An example of progressive welding is the welding of heavy sections where a V or U-groove joint is used and the welding is performed manually with covered electrodes. In flash welding the entire weld is completed simultaneously by the application of heat and pressure.

Welding processes differ also in the preparations required for welding. For many of the arc welding

Table 2—Recommended Welding Processes for Different Joint Designs*

Welding Process	Type of Joint‡								Overlay welding
	Butt joint (light)	Butt joint (heavy)	Lap joint (light)	Lap joint (heavy)	Fillet joint (light)	Fillet joint (heavy)	Edge joint (light)	Edge joint (heavy)	
Metal-arc (shielded)	S	R	R	R	R	R	NR	R	R
Submerged-arc	S	R	S	R	S	R	NR	S	R
Atomic hydrogen	R	S	S	S	S	R	R	S	R
Tungsten-arc (inert gas)	R	S	R	S	R	S	R	S	R
Metal-arc (inert gas)	NR	R	NR	R	NR	R	NR	S	R
Flash welding	NR	R	NA	NA	NA	NR	NA	NA	NA
Spot welding	NA	NA	R	R	NA	NA	NA	NA	NA
Seam welding	NA	NA	R	R	NA	NA	R	R	NA
Gas welding	R	S	R	S	R	S	R	S	R
Brazing (furnace)	NR	NR	R	R	R	R	NA	NA	NR
Brazing (torch)	S	S	R	R	R	R	S	S	S
Thermit	NA	R	NA	NA	NA	NA	NA	NA	NR

* R = Recommended S = Satisfactory NR = Not Recommended NA = Not Applicable
‡ Light: sections 0.005 to 0.125 in. Heavy: sections ⅛ in. and over

processes the welding groove must be prepared by either machining or gas scarfing of the joint. For some welding processes the surface of the metal must be clean for good electrical contact, as in resistance welding processes. The flash welding processes require clean metal surfaces at the electrode contact areas; a contaminated or dirty surface may result in excessive heating and produce defective welds.

The type of inspection methods which can be used to determine welding quality are varied. Welds that are made by any of the arc processes can readily be radiographed and inspected for soundness. Radiographic inspection is not entirely suitable for the inspection of flash welds because the weld is a narrow line. Welds made by some processes can be inspected by magnetic particle examination, while in other welding processes such as furnace copper-brazed joints, this method cannot be used.

Characteristics of Processes: Weld quality characteristics related to the various welding processes are:

1. Metallurgical
2. Physical
3. Mechanical
4. Chemical
5. Radiographic
6. Weld geometry
7. Appearance
8. Finishing.

In welds made by any of the arc welding processes, the physical and mechanical properties of the weld can vary widely according to the composition of the weld metal, which is governed by the composition of the filler metal. In the resistance welding processes, the physical and mechanical properties of the weld joint are governed by the properties of the parent metal and cannot be varied by chemical composition, since no filler metal is added and the composition of the welded joint is substantially the same as the parent stock. In arc welding, gas welding, brazing, and thermit welding, the mechanical and physical properties of the weld are influenced by the composition of the filler metal that is added to the weld and by the dilution with the parent stock. Consideration must therefore be given to the composition of the filler metal and to the degree of dilution in determining the mechanical properties which will be obtained in these processes. The physical and mechanical properties of the weld metal can be altered by heat treatment following the welding operation.

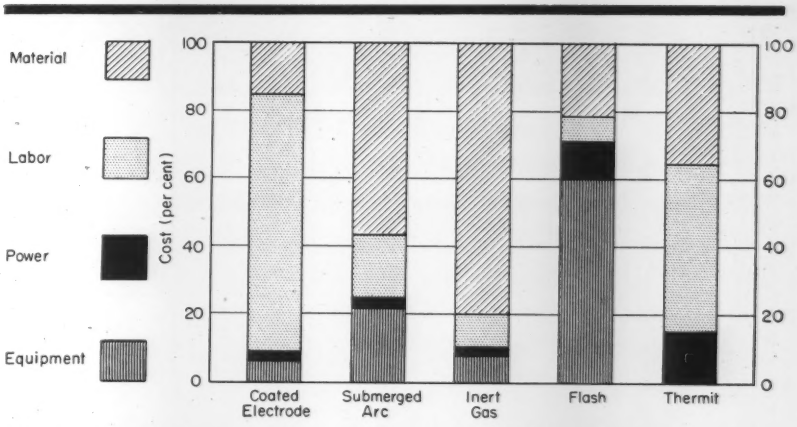


Fig. 2—Graph of comparative costs per unit for different welding processes emphasizes the need for careful analysis in selection

It is well known that the bare wire metal-arc welds contain excessive amounts of fine porosity. Filler wire compositions and electrode coating compositions also affect the quality of shielded metal-arc welds. Flux inclusions and porosity sometimes are found in the welds made by the torch-brazing processes.

Weld geometry, the form or shape of the weld, depends upon the joint design and the welding process used. The geometry of a weld made by the shielded metal-arc process may consist of a symmetrical weld, depending on the design of the welding groove. Butt welds are used with the arc welding process and are a continuation of the parent plate. In a resistance spot weld the geometry of the weld is usually in the form of a nugget joining two separate sections. The geometry of flash welds is entirely different than any other welds and is in the form of a line. The geometry of a copper-brazed weld joint differs from others in that it consists of a thin copper weld line joining the parts together.

The surface appearance of welds made by the inert-gas metal-arc process in some metals is clean, bright, and free from oxides, indicating complete shielding from the atmosphere. For a flash weld, characteristic of the process, the extruded metal is rough and irregular and in most applications is removed for appearance or inspection reasons. Submerged-arc welds generally can be identified by a very smooth surface appearance. Welds made by covered electrodes in the shielded metal-arc process can usually be identified by the characteristic surface appearance, as indicated by the ripples on the surface and slag indentations.

Composition of Metals: The composition of the metals to be welded largely governs the selection of the welding process. Some metals, like carbon steels, can be welded by most of the known welding processes. Other metals and alloys of special composition can only be welded by a few of the processes. Recommendations as to the type of processes most generally used are shown in TABLE 1. These recommendations are based on general applications and do not apply to special cases, or where special factors are to be considered.

Titanium and titanium alloys can only be welded at the present time with inert-gas tungsten arc, inert-gas metal arc, and a few of the resistance welding processes.

Welded Joint Design: Another factor which is of importance in

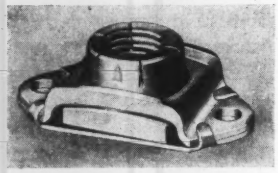
(*Continued on Page* 265)

NEW PARTS

FLOATING ANCHOR NUT 1

. . . saves installation and maintenance time

Nutt-Shel Co., 811 *Air Way, Glendale* 1, *Calif.*



Since the nut floats in a horizontal plane, location over the bolt is simple.

Size: $\frac{5}{16}$ and $\frac{3}{8}$-in.

Service: Replace fixed anchor nuts of AN366F and AN362F type; meet applicable requirements of specification AN-N-10; pushoff and torque tests caused attaching $\frac{3}{32}$-in. Al7ST aluminum alloy rivets to fail without damage to nut.

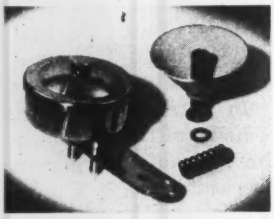
Design: Two-lug floating anchor; nut floats $\frac{1}{32}$-in. in horizontal plane; carbon steel, cadmium plated.

For more data circle MD 1, Page 207

OIL FILTER 2

. . . has permanent metal filtering element

Permanent Filter Corp., 2309 *Riverside Dr., Los Angeles* 39, *Calif.*



Eliminating cartridge pack replacements, this filter requires only periodic washing of the filtering element.

Designation: Filterall 200.

Size: $3\frac{5}{8}$ in. high.

Service: Filtering foreign matter as small as 5 microns from oil; will not by-pass cold, thick oil; no oil lost through absorption; holds sludge, dirt, metal and lacquer.

Design: Cone-shaped filtering element of porous sintered bronze; only one bolt is needed to mount filter; conversion filter-element kits available.

Application: Passenger cars, light trucks, airplanes, tractors, machine tools, boats, motorcycles.

For more data circle MD 2, Page 207

PHENOLIC PLASTIC 3

. . . absorbs shock and impact

Durez Plastics & Chemicals Inc., North Tonawanda, N. Y.

Having a synthetic rubber filler, this plastic absorbs shock more readily than standard flock or wood-flour filled materials.

Designation: 14780 Black.

Form: Molding compound.

Service: Resists shock, and has impact strength approximately 50% higher than standard materials; low modulus of elasticity, permitting molding in thin sections around inserts.

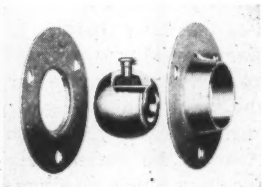
Properties: Phenolic plastic with synthetic rubber filler; flexural strength, 9000 psi min; tensile strength, 6000 psi min; temperatures to 250 F; good surface finish; can be molded by compression or closed-mold molding; may be preformed in automatic preforming equipment.

For more data circle MD 3, Page 207

FLANGE-MOUNTED BEARING 4

. . . self-aligning and compact

Randall Graphite Bearings Inc., 1011 *S. Greenlawn Ave., Lima, O.*



This unit is specially designed for light shaft duty and power takeoff application.

Size: With sintered or graphited bushings, for $\frac{1}{2}$, $\frac{5}{8}$ and $\frac{3}{4}$-in. shafts; with graphited, for $\frac{15}{16}$ and 1 in.; $3\frac{1}{2}$ in. diam, $1\frac{1}{4}$ in. long.

Service: As self-aligning bearing for light duty; self-lubricating.

Design: Stamped 16-gage steel flange conforms to spherical shape of machined cast-iron hollow ball; space between ball and sintered or graphited sleeve bearing is packed with SAE No. F-11 wool felt, and acts as reservoir for oil; oil is fed to bearing surface by capillary action.

For more data circle MD 4, Page 207

NEW PARTS

PANCAKE-HEAD SCREW 5

. . . molds into rubber or plastic parts

Shakeproof Inc., St. Charles Rd., Elgin, Ill.

The enlarged pancake-hexagon head provides holding and turning power for thread cutting.

Designation: Type 25.

Size: Size 2 to $\frac{5}{16}$-in.; lengths from $\frac{3}{16}$ to $1\frac{3}{4}$ in.

Service: As self-tapping fastener in plastics; can be molded into rubber or plastic; pancake surface provides holding power; hexagon feature prevents screw from turning in molded-on part; large thread-cutting slot provides low-torque driving in plastic without chipping or breaking.

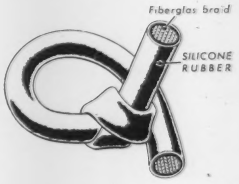
Design: Pancake-hexagon head with self-tapping screw thread.

For more data circle MD 5, Page 207

FIBERGLAS-SILICONE SLEEVING 7

. . . has high heat resistance, flexibility

Bentley, Harris Mfg. Co., Hector & Lime, Conshohocken, Pa.



This NEMA class H insulation has been treated to retard fraying.

Designation: BH 1151.

Size: 36 in. lengths, coils, or short pieces cut to specifications.

Service: Dielectric strengths of 1500 to 7000 v per mil; retains flexibility and rated dielectric strength through temperature range of −90 to 400 F, with spot temperature resistance to 600 F; treated to retard fraying; will not support fungus growth; meets NEMA class H specifications for grades A-1, B-1, C-1 and C-2.

Design: Braided Fiberglas tubing coated with silicone rubber; natural (off-white) or in colors.

For more data circle MD 7, Page 207

MOTOR-SPEED CONTROL 6

. . . provides fast starting and reverse

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

For use with a compound-wound ¾-hp motor, this unit is nonelectronic and provides strong dynamic braking.

Designation: 1702-A Variac.

Size: 13 in. long, 15 in. high, $5\frac{3}{8}$ in. deep, excluding knobs; weight, 41 lb.

Service: Variable-speed control of ¾-hp compound-wound motor; speed range, motor rated speed down to zero at constant torque; input, 105-125 v, 60 cycles ac (210-250 v transformer available); armature supply, 6.5 amp continuous at 0-115 v dc; field supply, 0.4-amp max at 115 or 75 v dc; input power, 65 w standby, 1150 w full-load; magnetic circuit breaker permits heavy starting current but opens between 7.25 and 9 amp on sustained armature overload; strong braking action in *stop* switch position.

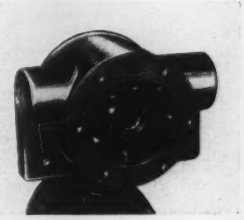
Design: Bridge-connected selenium rectifier fed by autotransformer supplies adjustable armature voltage, with fixed shunt-field voltage supplied by transformer and rectifier system; manually operated *start-stop-reverse* switch; available with or without motor.

For more data circle MD 6, Page 207

HARD-RUBBER PUMP 8

. . . for acids, alkalies, corrosives

American Hard Rubber Co., 93 Worth St., New York 13, N. Y.



This pump is said to deliver more liquid, within its pressure range, than any other pump in its size and price class.

Designation: Ace Jabsco.

Size: ¾-in. pipe ports.

Service: Pumping viscous or thin acids, alkalies, metallic salt solutions, inorganic acids, hydrochloric acid or any liquid not affecting the neoprene impeller; delivers 15 gpm at 9 psi or 5 gpm at 31 psi; max capacity, 41 psi or 16 gpm; self-priming against suction lifts of 6 ft without foot valve; handles 14 ft suction lifts when primed; impeller is self-lubricated, self-compensating for wear.

Design: Supplied as pump, motor and base; molded hard-rubber pump casing, cover plate, gland parts and drip pan; flexible neoprene impeller; Hastelloy C shaft, impeller insert, and key; close-coupled to ½-hp, 1140 rpm polyphase motor; stainless-steel mounting bolts and stud; cast-iron base painted with acid-resistant paint; pump is reversible.

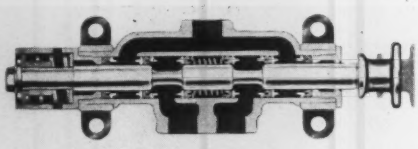
For more data circle MD 8, Page 207

NEW PARTS

"NEUTRAL" VALVE 9

. . . stops and holds cylinders in position

Valvair Corp., 953 Beardsley Ave., Akron 11, O.



Maintenance-free operation of over 20 million cycles is claimed.

Size: For ¼, ⅜, ½, ¾ and 1 in. pipe.

Service: Controlling air, water, oil or inert-gas operation of single or double-acting cylinders; stops and holds cylinder in any position; pressure to 300 psi.

Design: Spring-centered neutral; 3 and 4-way piped exhaust; in neutral position all ports are blocked (open neutral can be furnished); available with knob, lever, foot, clevis, double-acting cylinder, or double-acting cylinder with solenoid pilot valves as operator; bronze body; stainless-steel stem, hard chrome plated; Hycar O-ring packers with brass spacers; cadmium plated springs.

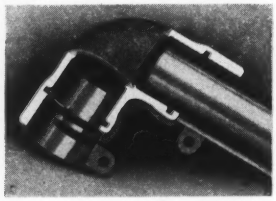
For more data circle MD 9, Page 207

STAINLESS FITTINGS 11

. . . join without threading or welding

Peter A. Frasse & Co. Inc., 17 Grand St., New York 13, N. Y.

Pipe or tube is inserted in the fitting and the clamp is tightened with an ordinary hex wrench, completing the coupling.



Designation: Quikupl.

Size: Tube sizes of ¾, 1, 1¼, 1½, 2, 2½, 3½, 4 and 4½ in.; pipe sizes of ¾, 1, 1½, 2, 2½, 3, 3½ and 4 in.

Service: Joining pipes or tubes carrying pressures to 150 psi; temperatures to 275 F, depending on corrosive agent involved; free flow with little turbulence and pressure drop.

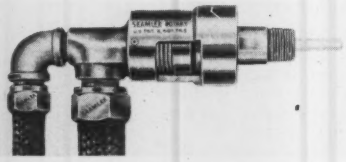
Design: Clamp is an integral part of fitting; tube is inserted into fitting, forcing a resilient synthetic sealing ring contained in a groove in the bore of the fitting into a "squeeze fit" regardless of pipe or tube tolerance; pressure in line from either direction of flow jams seal into positive fit with tube or pipe; available as tees, 90 or 45 deg elbows, couplings, reducing couplings, or male pipe-thread adapters in types 304 or 316 stainless steel.

For more data circle MD 11, Page 207

ROTARY JOINT 10

. . . adjustable for wear of rotary seal

Seamlex Co. Inc., 4123 24th St., Long Island City, N. Y.



Floating rotary seal is self-aligning in any direction.

Designation and Size: 9-P and 8-S for ½-in. pipe; 13-P and 12-S for ¾-in.; 17-P, 16-S for 1 in.; 21-P, 20-S for 1¼ in.; P denotes one-way flow type—S denotes siphon type.

Service: Rotating connection for steam, water, air, or vacuum up to 150 psi; 350 rpm; temperatures to 350 F; rotary seal is self-aligning axially and radially; rotary seal is relieved of excessive pressure, and consequent friction and wear, by pressure equalizing chamber.

Design: Self-lubricating graphite rotary seal; spring-action bellows holds seal in position; external screw adjustment compensates for normal seal wear; ball or self-lubricating bearing, depending on service; rotary shaft of hardened alloy steel with hardened wearing surface.

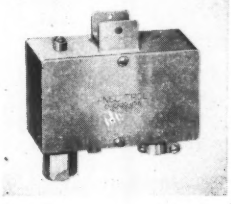
For more data circle MD 10, Page 207

TIME DELAY SWITCH 12

. . . adjustable over 20 to 1 timing range

Pneu-Trol Devices Inc., 1438 N. Keating Ave., Chicago 51, Ill.

Originally designed to provide a controlled time dwell at the end of a cylinder stroke (with auxiliary solenoid valve), this unit can initiate time-controlled *on* or *off* periods in auxiliary equipment.



Size: 4⅛ in. long, 3⅜ in. high (less pin and lever bracket), 1⅞ in. wide.

Service: Providing adjustable time delay when actuating pin is depressed in 20:1 range; total possible range ¼ to 60 sec by changing viscosity of oil in dashpot; switch is rated 10 amp at 125 v ac, 5 amp at 250 v ac or 3 amp at 460 v ac; silicone fluid may be used if switch is subject to wide temperature variation; actuating pressure on pin, 3 lb.

Design: Single-pole double-throw switch can be used normally open, normally closed or double-throw, can be furnished double-pole double-throw; when hardened, ball-tip operating pin is depressed, energy is built up in actuating spring, causing piston in dashpot to move down slowly through viscous oil; when switch is tripped and pressure removed, return spring resets piston and pin; supplied with right or left-hand positions with direct, downthrust, upthrust, horizontal or roller actuation.

For more data circle MD 12, Page 207

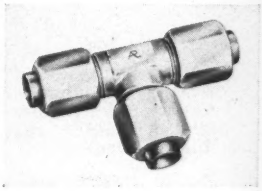
NEW PARTS

ALUMINUM FITTINGS 13

. . . available as standard stock items

Parker Appliance Co., 17325 *Euclid Ave., Cleveland* 12, *O.*

Aluminum tube fittings for industrial applications are now available, to help meet the shortage of copper.



Size: For ¼, 5/16, ⅜ and ½-in. OD tubing.

Service: Connection of aluminum tubing systems; resists corrosion and reaction with fluids; lightweight.

Design: Three-piece flared fitting design; available as male and female connectors, elbows, tees, unions and tube end reducers.

Application: Refrigerators and air conditioning units; coolant and lubrication systems for machine tools; fuel systems for trucks, pumps and diesel engines.

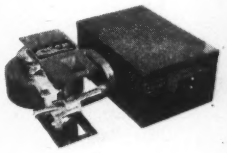
For more data circle MD 13, Page 207

ELECTROMAGNETIC PUMP 14

. . . moves molten or liquid metals

General Electric Co., Special Products Section, Schenectady 5, *N. Y.*

Having no moving parts, this unit can pump low-resistance conducting fluids at temperatures up to 1000 F.



Designation: 9159849G4.

Size: Cell, 10 in. long, 1 in. standard pipe; transformer unit, 19 in. long, 13 in. wide, 12 in. high; capacitor unit, 22 in. long, 15 in. wide, 10 in. high.

Service: Pumping fluids which (1) can wet stainless steel, (2) have an electrical resistivity less than or equal to stainless steel (approx 90 microhm-cm), (3) are fed into the inlet at sufficient head to keep cell full; can pump liquid metals such as sodium, sodium-potassium alloys and lithium; temperatures to 1000 F; pumps approx 28 gpm at 20 psi, varying with pressure; requires adjustable autotransformer (not supplied) with 30 amp, 0 to 270 v ac output which operates from 230 v, 30 amp.

Design: Transformer sets up high current in liquid metal contained in Type 347 stainless-steel cell, so that fluid acts as a current-carrying conductor; magnetic current is set up perpendicular to that current, moving liquid; capacitor unit provides power-factor correction.

For more data circle MD 14, Page 207

HIGH-ADDITIVE OIL 15

. . . combats sludge and engine wear

Shell Oil Co., 50 *W. 50th St., New York, N. Y.*

Advantages have been most pronounced in diesel engines designed for high output on low-grade fuels.

Designation: Rimula.

Form: SAE 10, 20 and 30 oil.

Service: For low-temperature intermittent idling operation of gasoline and diesel engines, also high-temperature and high-load diesel operation; cuts down engine wear from corrosion and fouling, particularly in intermittent operation; eliminates ring sticking, plugging and varnish deposits; resists breakdown.

Properties: High alkaline additive concentration with low depletion rate and highly dispersive action.

Application: Materials handling equipment; tractors; stationary diesels; pickup trucks.

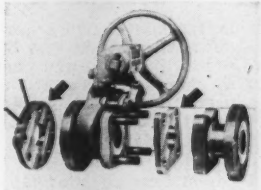
For more data circle MD 15, Page 207

HEATED VALVES 16

. . . remain clear of frost and ice

Okadee Co., 332 *S. Michigan Ave., Chicago* 4, *Ill.*

Designed for liquid carbon dioxide lines, these valves are also applicable to hot, cold and viscous liquid and gas lines.



Size: Flanged valves from 1 to 6 in. diam.

Service: For extreme temperature conditions; valve mechanisms operative at temperatures as low as −110 F; heat from elements is transmitted directly to valve seats, heating the entire flow opening as well as operating mechanism; input, 400 to 3000 w per unit; 110 or 220 v; heated valves for hazardous atmospheres available soon.

Design: Heating units, 1 in. thick, may be installed singly or in multiples, and are available in 2 types—(1) internal (right of photo) for Okadee valves only, (2) for standard ASA flanged valves (left of photo); present flanged valves may be converted by exchanging standard stud for 1 in. longer studs; valves are available with pneumatic, hydraulic, solenoid or manual control.

For more data circle MD 16, Page 207

NEW PARTS

ORGANIC PRIMER 17

. . . also metal passivator and pretreatment

Lankote Div., J. Landau Co., 220 Wooster St., New York 12, N. Y.

This primer plus usual topcoats has as much salt-spray resistance as phosphatized parts with the same topcoats.

Designation: PR-1.

Form: Supplied as base solution and diluent which are mixed in 4 to 1 ratio, respectively, not over 8 hr before use.

Service: Provides over 500 hr salt-spray resistance without corrosion or creeping; can be brushed, sprayed or roller-coated; air-dries in 30 min, or may be baked; excellent adhesion on ferrous, nonferrous or galvanized metal because of half mechanical, half chemical bond caused by etching action of acid diluent; must be used as undercoat.

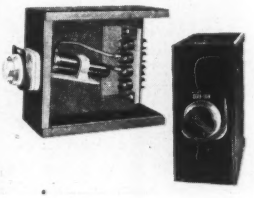
Properties: Zinc-chromate, phosphoric acid washcoat primer which includes rust inhibitors; tensile strength, 3000 psi; water absorption, 1 to 2% for ⅛-in. film thickness per 24 hr; volume resistivity (50% relative humidity, 25 C), 5×10^{10} ohm-cm; dielectric strength (step-by-step, ⅛-in. film), 325 v per mil.

For more data circle MD 17, Page 207

MERCURY SWITCH 19

. . . safe for hazardous locations

Tigerman Engineering Co., 4332 N. Western Ave., Chicago 26, Ill.



Any possibility of a spark is eliminated because of the all-mechanical nature of the actuating linkage.

Designation: 800, 900.

Size: 5⅛ in. high, 2⅜ in. wide, $6\frac{7}{16}$ in. deep.

Service: 800 for 20 amp, 900 for 35 amp, 120 v 60 cycles ac noninductive load; for Class 1, Group 2 hazardous locations.

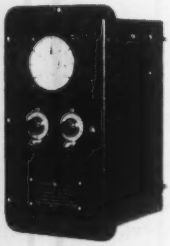
Design: Single or double pushbutton or selector-switch operators; single-pole, single or double throw; normally open or closed; double switches can be furnished with any combination of selectors or pushbuttons; stainless-steel mercury bottles with plastic covering; spring action returns pushbutton switch to original position with release of finger pressure.

For more data circle MD 19, Page 207

DIFFERENTIAL INDICATOR 18

. . . shows differences in volts, amps, speed

General Electric Co., Meter and Instrument Dept., Schenectady 5, N. Y.



Difference between any two quantities which can be converted to voltage can be measured, and the output used to operate a recorder, indicating instrument or alarm relay.

Designation: 9888820G1 with semiflush mounted indicating instrument; G2 without instrument.

Size: 16¾ in. high, 9¾ in. wide, 9⅜ in. deep.

Service: Measuring a 0.001 to 30 v differential of 2 input voltages ranging from 1 to 400 v dc, providing they do not differ by more than 300 to 1; can be set to indicate full scale for differentials as small as 0.022-v; high degree of stability and freedom from drift; can be used with standard external signal generators to measure differential amp, fpm, psi, temperature, etc.; input resistance, 1.5 megohm; output, 2.5-0-2.5 or 0-5 ma into 1200 ohm circuit resistance; repeatability, ±0.05% of applied v or ±1.5% full scale, whichever is greater.

Design: High-resistance precision voltmeter containing an electronic amplifier; can operate recorder or alarm signal; two dials provide adjustment.

For more data circle MD 18, Page 207

COOLING SYSTEM FILTER 20

. . . reduces wet-sleeve pitting in diesels

Spark-O-Liner Corp., 601-11 Ave. S., Minneapolis 4, Minn.

Cathodic current is generated, inducing corrosion to attack "sacrificial" plates in the filter, rather than metals in the cooling system.

Designation and Size: TB, for 8 to 16 gal capacity cooling systems; TB Special, for 15 to 30 gal; P, for up to 24 qt; E, for 5 to 10 gal.

Service: Reduces wet-sleeve pitting in industrial diesel cooling systems by generating small cathodic current which induces corrosion to attack corrosion-resistor plates in the filter rather than causing galvanic corrosion in minute areas not protected by rust-inhibitor film; removes mineral hardness and dissolves previously deposited scale; filters out insoluble particles; neutralizes acid or alkaline conditions.

Design: Synthetic ion-exchange bed removes hardness; replaceable elements; chemically activated element releases buffering agent to neutralize acids and alkalis; used with by-pass hose connections similar to water heater, with water returned to suction side of the pump.

For more data circle MD 20, Page 207

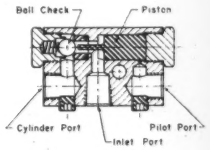
NEW PARTS

PILOT CHECK VALVES 21

. . . operate on low pilot pressure

Fluid Controls Inc., P.O. Box 186, *Willoughby, O.*

Unseating of check ball occurs on application of pilot pressure even when locked pressure exceeds relief pressure setting of the system.



Designation: 25200.

Size: For ¼ or ⅜-in. pipe sizes; $3\frac{9}{16}$ in. long, 1 in. wide, 2 in. high.

Service: Locking a cylinder or part of a circuit where slight leakage would cause loss of clamping pressure; will hold clamping pressure indefinitely; for 3000 psi.

Design: Permits free flow from inlet to cylinder port; blocks reverse flow until pressure applied at pilot port causes internal piston to lift ball check valve from seat; piston has area 4 times that of check valve seat, reducing pilot-port pressure; steel ball check cannot stick open, has limited travel to prevent spring damage; hardened steel check seat with diamond-lapped sealing surface; heat-treated piston, centerless ground to close slide fit; small piston end is annealed to prevent damage to ball; piston travel limited by shoulder; piston action is damped to prevent impact.

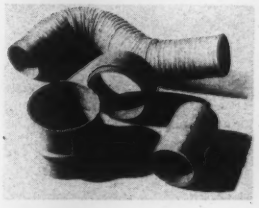
For more data circle MD 21, Page 207

TUBULAR PARTS 23

. . . of glass fiber plus silicone rubber

Arrowhead Rubber Co., Silicone Dept., 11634 *Patton Rd., Downey, Calif.*

Ducting, sleeves and couplings can be fabricated to resist high and low temperatures.



Designation: ArcoSil 2184

Size: ¾ to 15 in. ID in increments of ¼-in.; larger sizes or special shapes to specification.

Service: For high and low-pressures at temperature to 700F: remain flexible at −125 F; resist aging, ozone and most corrosive fluids and gases; comparatively high abrasion resistance.

Design: Silicone-rubber impregnated glass fiber fabricated into (1) helical-wire supported flexible ducting and tubing, (2) convoluted and sleeve type flexible couplings for hot air ducts, (3) hose suitable for handling air at 700 F and 2000 psi, (4) die-cut high-temperature gaskets, (5) fabric-covered sponged silicone seals; can be bonded to metal; parts can be fabricated with built-in tees, elbows, flanges and other special features.

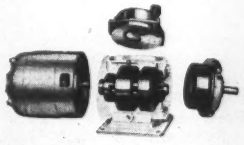
For more data circle MD 23, Page 207

VARIABLE-SPEED TRANSMISSIONS 22

. . . for low-power, high accuracy service

Graham Transmissions Inc., 3754 *N. Holton St., Milwaukee* 12, *Wis.*

Providing a wide speed range, this transmission is available with or without motor and gear reduction or step-up, and with several different controls.



Designation: Model 18; St'd, W, R & S, or T type.

Size and Service: Providing continuously variable speed from 1800 rpm input; output, zero to desired max; 1/15-hp; accurate speed holding; resets accurately to desired speed; speeds can be changed while running or stationary; dimensions with open-type 3-phase motors and standard manual control as follows:

Designation	Reduction	Length* (in.)	Width (in.)	Height (in.)
St'd	Standard	$12\frac{5}{16}$	$4\frac{5}{8}$	$6\frac{1}{2}$
W	Worm	$13\frac{15}{16}$	$4\frac{5}{8}$	$6\frac{1}{2}$
R & S	Spur and step-up	$14\frac{7}{32}$	$4\frac{47}{64}$	$6\frac{33}{32}$
T	Double spur	$16\frac{9}{16}$	$7\frac{27}{64}$	$8\frac{47}{64}$

*Add 1 in. for single-phase or totally enclosed nonventilated motors.

Design: Tapered rollers and traction ring with compound planetary gear; micrometer control is standard, with single-turn, lever, remote mechanical and remote electric controls available.

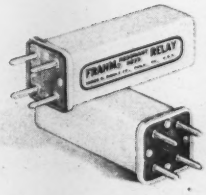
For more data circle MD 22, Page 207

RESONANT-REED RELAY 24

. . . tuned to respond to modulated signals

James G. Biddle Co., 1316 *Arch St., Philadelphia* 7, *Pa.*

Tuned steel reeds operate these relays upon receiving low-frequency signals.



Designation: Frahm 3303-5 to -20.

Size: 2¼ in. high, $\frac{37}{64}$ in. square; mounts in No. 9804 crystal socket.

Service: Relay operation upon reception of a definite-frequency signal from a signal generator, received on wire line or as a modulated carrier; multiple control signals can be sent on a single channel; duration of contact from 5 to 20% of nominal relay period; operating level, 25 amp-turns; coil resistance, 60 ohm; band width at operating level, ±0.6%—at 3 times operating level, ±3.5%; available for frequencies as follows;

No.	Frequency (cps)	No.	Frequency (cps)	No.	Frequency (cps)
-5	500.2	-11	346.6	-16	255.4
-6	470.5	-12	326.0	-17	240.2
-7	442.6	-13	306.7	-18	226.0
-8	416.3	-14	288.6	-19	212.6
-9	391.8	-15	271.3	-20	200.0
-10	368.3				

Design: Tuned carbon-steel or alloy reed vibrates when modulated electrical signal of proper frequency passes through relay coil; vibration of reed closes contacts; auxiliary relay can be used when steady closed contact is needed; specials available.

For more data circle MD 24, Page 207

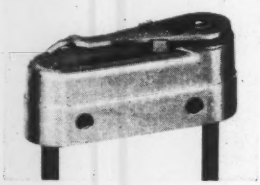
NEW PARTS

SEALED SWITCH 25

. . . can be completely immersed in water

Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Terminal leads are potted and waterproof and the contact chamber is hermetically sealed.



Designation: 4HS.

Size: $1\frac{13}{16}$ in. long, $\frac{11}{16}$-in. wide, $\frac{33}{32}$-in. high.

Service: Waterproof and hermetically sealed for locations subject to immersion, moisture or dirt; rated 10 amp inductive or 25 amp resistive load at 28 v dc, 1 amp inductive or resistive at 125 v ac; operating force, 16±6 oz; release, 4 oz min; pretravel, 0.065-in. max; differential travel, 0.020-in. max; overtravel, 0.010-in. min.

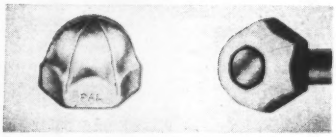
Design: Single-pole single-throw, or double-throw; metal switch case is sealed at top by a metal diaphragm through which the external actuating lever operates; contact chamber is filled with inert gas under pressure and sealed; waterproof leads are potted in high-dielectric black epoxy casting resin; leads of any length are available, as well as waterproof couplings.

For more data circle MD 25, Page 207

ACORN NUTS 27

. . . push onto unthreaded rod

Palnut Co., 61 Cordier St., Irvington 11, N. J.



Designed for light-duty decorative applications, these nuts eliminate threading, notching or cotter pins.

Designation and Size: Pushnut C for $\frac{3}{16}$ and ¼-in. rod. K for $\frac{3}{16}$, ¼ and $\frac{5}{16}$-in. rod.

Service: Permanent, decorative applications, with removal resistance of 100 lb or more; pushed on with fingers or hammer-tap; automatically applied straight in line.

Design: Heat-treated spring steel acorn (C) or open-end (K) nuts; tempered after forming and plated in various finishes; 3 gripping fingers at circular opening plus 6 points on teeth inside nut provide removal resistance.

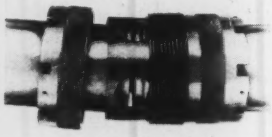
Application: Doll carriages, toy wagons, wheelbarrows and wheeled vehicles.

For more data circle MD 27, Page 207

TUBE COUPLINGS 26

. . . permit axial, radial tube misalignment

E. B. Wiggins Oil Tool Co. Inc., 3424 E. Olympic Blvd., Los Angeles 23, Calif.



Tube ends may be separated as much as ½-in.

Designation: Flexomatic.

Size: Per AND 10058 and 10060 with dash numbers and sizes as follows;

No.	Tube OD (in.)	Diam (in.)	Length (in.)	No.	Tube OD (in.)	Diam (in.)	Length (in.)
16	1	1.53	1.88	40	2½	3.33	2.28
20	1¼	1.78	1.88	48	3	3.68	2.28
24	1½	2.33	2.28	56	3½	4.46	2.38
28	1¾	2.58	2.28	64	4	4.96	2.38
32	2	2.83	2.28				

Service: Connecting tubing at pressures in excess of 375 psi; temperatures from −65 to 460 F on fuel and oil lines; tube ends may be separated up to ½-in.; coupling may be misaligned up to 3 deg without breaking seal.

Design: Installation nut over mating body compresses two AF 934 O-ring seals; tubing requires machined beads or rolled beads per AND 10058 or AND 10060, respectively for sizes through −48, and beads dimensioned like −48 for larger sizes; end-load is absorbed by metallic retainer.

For more data circle MD 26, Page 207

STAINLESS STEEL 28

. . . combines fatigue, corrosion resistance

Armco Steel Corp., Middletown, O.

Marked corrosion resistance, along with excellent yield strengths in compression and tension, flexural endurance and high-temperature properties, make this precipitation-hardening steel versatile.

Designation: 17-7 PH.

Form and Service: Can be deep drawn and severely formed; corrosion resistance better than most hardenable stainless steels; high strength to weight ratio; high strength at temperatures to 800-900 F; excellent corrosion-fatigue properties; good welding characteristics; good machinability in annealed, solution-treated or hardened condition; good forging and casting alloy.

Properties: Composition is C 0.07, Cr 17.00, Ni 7.00, Al 1.10, rest Fe; density (condition A), 0.282-lb per cu in.; resistivity, 81 microhm-cm; coefficient of thermal expansion, 8.5 x 10^{-6} in. per deg F (70 to 200 F);

Condition*	Ultimate Tensile Str. (thousand psi)	Yield Strength (0.2% offset, thousand psi)	Elongation (% in 2 in.)	Hardness (Rockwell)	Modulus of Elasticity (million psi)
A[1,2,3,4,†]	130	40	30	B85	29
T[4,†]	145	100	9	C31	29
TH[4,†]	215	200	9	C45	29
THD†	205	195	9	C44	29
C[1,2,5]	215	185	2	C43	29.5§
CH[5,‡]	250	240	1	C49	29.5§

*Supplied by mill in: [1]sheets, [2]strip, [3]plates, [4]bars, [5]wire. †May be developed in sheets, strip, plates and bars. ‡May be developed in sheets, strip and wire. §Longitudinal; 32 million transverse.

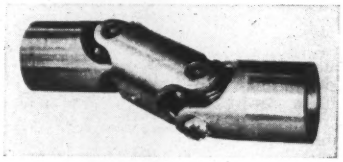
For more data circle MD 28, Page 207

NEW PARTS

UNIVERSAL JOINT 29

. . . durable in heavy duty service

Curtis Universal Joint Co., 4 Birnie Ave., Springfield, Mass.



All parts are heat treated and ground for maximum strength.

Size: 6 in. hub diam; single joint is 15½ in. long, weighs approx 98 lb; double joint is 25 in. long, weighs approx 155 lb.

Service: For heavy duty service; easily assembled and disassembled through use of a threaded small pin and locknut.

Design: Single or double; forks are cast of alloy steel; pins and blocks are of cold-drawn alloy steel; all parts are heat treated and ground; hubs are machined to specifications.

Application: Rolling mill equipment; strip slitting and leveling machinery; galvanizing equipment.

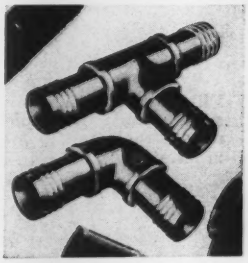
For more data circle MD 29, Page 207

CLAMP COUPLINGS 31

. . . join flexible plastic pipe lines

Carlon Products Corp., 10225 Meech Ave., Cleveland 5, O.

These ell and tee clamp-on fittings, together with straight insert clamp couplings and threaded tees, ells and unions make possible all types of installations.



Size: For standard pipe sizes to 2 in.; larger sizes, special.

Service: Joining flexible plastic pipe; positive, leak-proof joint; will not rot, rust or corrode electrolytically.

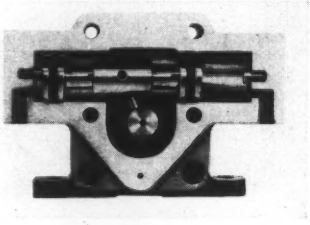
Design: Ell and tee types; male, serrated ends are inserted into plastic pipe, and stainless-steel clamps are tightened over pipe and fitting to form joint; insert adapters are available for joining plastic pipe to metallic system, and are designed with one serrated end and one male threaded end.

For more data circle MD 31, Page 207

POWER OPERATED VALVE 30

. . . for air, oil or water

Ledeen Mfg. Co., 1600 S. San Pedro St., Los Angeles 15, Calif.



Several types of pilot-valve actuation are available.

Designation: POV.

Size: ⅜, ½ and ¾-in. pipe size—½-in. internal ports, 6 in. long, 5 1/16 in. wide, 4 1/16 in. high; ¾, 1 and 1¼ in. pipe—1 in. internal ports, 10¼ in. long, 8 5/16 in. wide, 6½ in. high.

Service: Controlling air, oil or water; can be actuated by finger or toe-operated, cam-operated or solenoid-operated pilot valves; can be used in remote-control, automatic operation, reciprocating operation, or "fail safe" systems.

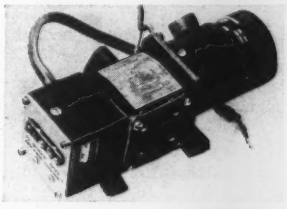
Design: 4-way disk valve is rotated by a crank, operated by a piston; pressure applied at either end of the piston is controlled by pilot valves.

For more data circle MD 30, Page 207

ROTARY ACTUATOR 32

. . . has wide temperature and altitude range

Hydro-Aire Inc., 3000 Winona, Burbank, Calif.



Designed to drive remote mechanisms through flexible shafting, this unit is very light in weight.

Size: 3 in. long, 2.75 in. wide, 1.25 in. high; weight, approx 5 lb 6 oz.

Service: Intermittent rotary drive with 13 lb-in. torque output at 2900 rpm; operation is 1 min on, 19 min off; brake stops output shaft within approx 10 turns; rated at 0.6-hp; operates at all altitudes up to and including 50,000 ft, in temperatures from −65 to +200 F; for 220 v, 400 cycle, 3-phase ac current; can be adapted to 24 v dc operation; motor is protected against thermal overload, internal condensation and entrance of foreign matter.

Design: 3-phase motor drives rotary actuator mechanism; limit switches control number of turns of output shaft; 3-phase ac brake; entire unit is mounted on 4 drilled pads.

For more data circle MD 32, Page 207

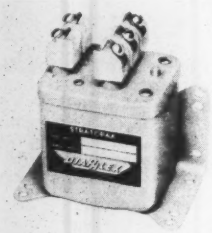
NEW PARTS

TIME DELAY RELAY 33

. . . has wide, adjustable delay range

Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

Eliminating thermal or shorted-turn principles, a new "rockshaft" motion is employed.



Size: 3⅛ in. high, 2 $\frac{1}{16}$ in. wide, 1¾ in. deep, without mounting; weight, 7½ oz.

Service: Time delay adjustable from 0.1 to 1 sec; time interval is independent of voltage; repeatability, ±3%; contacts rated 3 amp at 28 v dc noninductive, 1½ amp at 115 v ac inductive; operating rating, 14 to 29 v dc; qualifies under specification MIL-R-6106; slow release or slow operate, optional; continuous or intermittent power source.

Design: Snap-action contacts; hermetically sealed and pressurized with dry nitrogen; 2-position mounting is welded and copper-brazed to envelope.

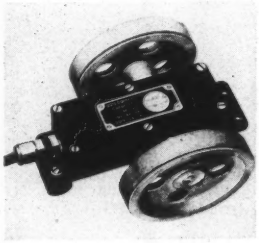
For more data circle MD 33, Page 207

ACTUATING SWITCH 35

. . . measures length of moving materials

Production Instrument Co., 702-08 W. Jackson Blvd., Chicago 6, Ill.

Continuous moving lengths of paper, fabrics, lumber, etc. can be measured with this switch plus an electric counter.



Size: 12 in. circumference wheels (other sizes available as specials); length 6 in.; width (less wheels), 1⅞ in.; height (less wheels), 1 $\frac{9}{16}$ in.

Service: Contact closure as function of linear actuation; each complete revolution of wheels closes and opens switch to register a count on an electric counter; contact springs are rated at 10 amp, 115 v ac.

Design: Bracket holds switch in fixed position, allowing measuring wheels to ride on and be turned by material being measured; contact springs are nickel silver with silver points; steel shaft; die-cast housing.

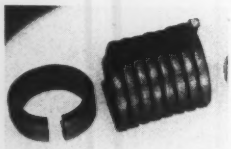
For more data circle MD 35, Page 207

PUMP PACKING 34

. . . resists hydrocarbon solvents

Sea-Ro Packing Co. Inc., Wood-Ridge, N. J.

According to the company, this packing will not swell, soften or disintegrate in aliphatic and aromatic hydrocarbons.



Designation and Size: 701 (spiral), ⅛ to 1⅛ in. in increments of $\frac{1}{16}$-in.; 705 (rings), to specifications.

Service: Resists aliphatic and aromatic hydrocarbons in pumps operating at temperatures to 550 F and 1000 psi; suitability for various solvents follows, with S indicating little or no swelling, G indicating generally suitable conditions with only moderate swelling or softening;

Acetone .....S	Cottonseed oils....S	Kerosene .....S
Acids .....G	Cresol .....G	Mineral oils .....S
Alcohol, ethyl..S	Dibutyl phthlate..G	Naphtha
Alcohol, amyl..S	Diethylene glycol..S	petroleum .....S
Alcohol, Benzyl.G	Dioctyl phthlate..G	Octane .....S
Alkalies .....S	Ethyl acetate.....S	Oils, mineral.....S
Animal oils,	Ethylene glycol...S	Oils, vegetable....S
fats .....S	Gasoline .....S	Phenol .....G
Benzene .....G	Gasoline, aviation.S	Propane .....S
Butyl acetate...G	Glycerine .....S	Toluene .....G
Butane .....S	Heptone .....S	Turpentine .....G
Carbon	Hexane .....S	Xylene .....G
tetrachloride .S		
Chloroform ....G		

Design: Woven cotton casing with shredded metal, asbestos and lubricating-graphite filler plus specially formulated binder.

For more data circle MD 34, Page 207

MIDGET SOLENOID VALVE 36

. . . has built-in time delay feature

Automatic Switch Co., 385-C Lakeside Ave., Orange, N. J.

Flow of liquid or gas is held back for a few seconds after the solenoid is energized.

Size and Service: ⅛-in. pipe size with $\frac{1}{16}$-in. ports for pressures up to 150 psi and 15 gph flow; overall height, 2 $\frac{3}{16}$ in.; time delay, approx 5½ sec; also available with ⅛-in. ports, time delay of approx 6½ sec, pressures to 125 psi and 40 gph flow; can be installed in any position; standard continuous-duty coil for 115 v, 60 cycles ac.

Design: 2 or 3-way solenoid-operated with built-in time-delay mechanism; brass or stainless steel body; stainless operating parts; soft composition disk for fast, positive shutoff.

Application: Oil burner fuel control; machine and instrument control systems.

For more data circle MD 36, Page 207

NEW PARTS

CONVEYOR BELTING 37

. . . highly resistant to vegetable oils

Baldwin Belting Inc., 76 Murray St., New York 7, N. Y.

A completely new type of Neoprene is used, and is now standard on all white Supertex belting.

Designation: Supertex.

Size and Service: Neoprene surface resists vegetable oils, has lower compression set over wide temperature range than natural rubber; contains no sulphur, thiuram disulfide or other compounds yielding free sulphur or vulcanization accelerator; washable, oilproof, waterproof, tasteless, odorless, nontoxic, and acid and alkali-resistant; suitable for temperatures to 250 F; ply adhesion, 12-17 psi; available in widths to 48 in.; cover thickness, heavy—$\frac{3}{64}$-in., standard —0.010-in.;

Property or Size	3-Ply	5-Ply
Tensile strength (lb per in. width)	420	700
Recommended load (lb per in. width)	48	80
Thickness: heavy (in.)	$\frac{1}{8}$	$\frac{3}{16}$
standard (in.)	$\frac{3}{32}$	$\frac{9}{64}$
Min pulley diam (in.)	1	$1\frac{1}{2}$

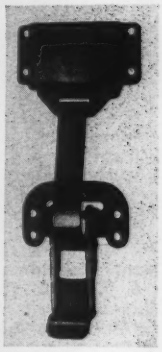
Design: Manufactured of closely woven 9.0 oz duck with 0.010-in. skim coat of Neoprene between all plies; Neoprene is type WRT, a new crystallization-resistant polymer.

For more data circle MD 37, Page 207

CLAMP AND LATCH 39

. . . uses coil spring to resist impact

Bassick Co., Bridgeport 2, Conn.



Tendency of many latches to open on impact has been minimized.

Designation: Power-Pack.

Size: Clamp—3.85 in. long, 1.5 in. wide (mounting hole center-to-center); striker assembly—0.680-in. long (center-to-center), 1.88 in. wide (center-to-center).

Service: Latch fastening with initial loads of 80 or 100 lb and working loads of 100 or 125 lb, respectively, depending on spring design; withstands severe vibration, shock and impact without opening; can be used in subzero temperatures.

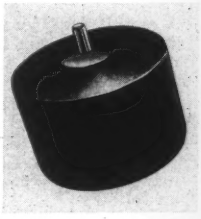
Design: Striker assembly contains 4 compression springs acting on striker plate to absorb shock loads; hot-rolled steel, hardened where necessary (except springs).

For more data circle MD 39, Page 207

STEPPING POSITIONER 38

. . . can drive low-torque mechanisms

G. M. Giannini Co., 254 N. Colorado St., Pasadena, Calif.



An external shaft and a potentiometer shaft are both rotated by a pulse input.

Designation: Roto-Stepper 8915-1, -2, -3, -4.

Size: 3.13 in diam; -1, 2.25 in. long; -2, 3.25 in. long; -3 and -4, 4.00 in. long.

Service: Rotation of external shaft and/or potentiometer shaft in 2 deg increments (1 to 10 deg, special) by pulses; responds to max of 720 impulses per min with minimum length of 0.05-sec; accepts pulses at rate up to 30 per sec, depending on torque; torque output varies with pulse rate, is approximately 12 oz-in. at 12 pulses per sec; current, 0.6-amp max at 24 v at 25 C; torque detent spring prevents reverse rotation of output for torque not exceeding 1.5 oz-in.; withstands $\pm 6g$ steady acceleration, or excursion of 0.02-in. double-amplitude sinusoidal vibration of 10-55 cps along 3 major axes for 15 min.

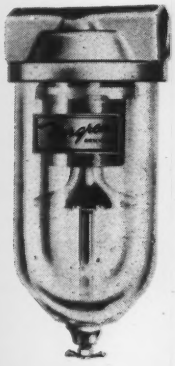
Design: Solenoid-operated; shaft output (-1), plus potentiometer output (-2), plus homing segments (-3), plus internal autocycling (-4); -2, -3, and -4 available without shaft output.

For more data circle MD 38, Page 207

AIR-LINE FILTER 40

. . . shows water in transparent plastic bowl

C. A. Norgen Co., 3400 S. Elati St., Englewood, Colo.



Three interchangeable filter elements are available.

Designation and Size: $5\frac{1}{4}$ in. diam, $11\frac{7}{16}$ in. high; 22B-6 for $\frac{3}{4}$-in. pipe; 22B-8 for 1 in. pipe; 1 pint bowl.

Service: Removing moisture, pipe scale and other foreign matter from compressed air lines; air flow from 0 to 140 cfm at 0 to 150 psi pressure and 40 to 120 F temperature; bowl is easily removed for cleaning or replacement.

Design: Transparent plastic bowl with 74-micron (200 mesh) Monel metal screen, or 25 or 64-micron sintered-metal filter elements; baffle plate traps moisture and solids at bottom of bowl; collected water and solids are blown out by opening drain cock; lower entry ports and deflector ring set up a centrifugal force that removes high percentage of moisture; O-ring seal at body and bowl connection and at drain cock.

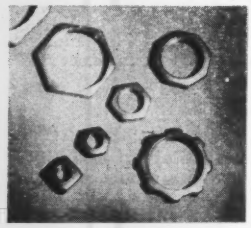
For more data circle MD 40, Page 207

NEW PARTS

COLD-PUNCHED NUTS 41

. . . now available in three types

Jacobson Mfg. Co. Inc., Kenilworth 3, N. J.



New manufacturing methods make possible substantial savings and fast delivery, according to the company.

Size: Machine screw nuts (square or hex), Nos. 4, 5, 6, 8, 10, 12, and ¼-in.; conduit locknuts, ⅛, ¼, ⅜, ½, ¾, 1, 1¼, 1½ and 2 in.; minimum quantity, one standard keg; specials available up to 2 in. diam (max dimension).

Service: Conduit locknuts are UL-approved; manufactured to established quality standards.

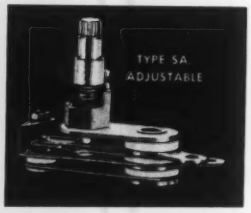
Design: Cold-punched from steel, brass or stainless steel, with machined threads; cadmium or zinc plating available.

For more data circle MD 41, Page 207

BIMETAL THERMOSTATS 42

. . . for narrow or wide differentials

Stevens Mfg. Co. Inc., 69 S. Walnut St., Mansfield, O.



Differential between make and break of circuit can be as narrow as 10 F or as wide as 100 F.

Designation and Size: $\frac{33}{64}$-in. wide;

Type	Length* (in.)	Body Height (in.)	Overall Height (in.)
SA (adjustable)	$1\frac{5}{8}$	$\frac{17}{32}$	†
SA (nonadjustable)	$1\frac{5}{8}$	$\frac{17}{32}$	$\frac{7}{8}$
SM	$1\frac{1}{16}$	$\frac{5}{8}$	†

*Without terminals. †Depends on stem length specification.

Service: Temperature differentials from 10 F to 100 F; electrically independent bimetal eliminates artificial cycling; positive contact pressure until contacts snap open reduces arcing; rated 15 amp at 120-240 v ac and 30 v dc (higher ratings, special).

Design: Snap acting; single-pole single-throw or single-pole double-throw; SM is adjustable, with manual reset; SA nonadjustable model is preset by sealing adjusting screw at factory; stems supplied in any length, with knurled or slotted heads; mounts with single screw or rivet; standard, elevated or special terminals.

For more data circle MD 42, Page 207

MELAMINE-GLASS MAT INSULATION 43

. . . has good electrical characteristics

Synthane Corp., Oaks, Pa.

Representing a considerable saving in cost below NEMA grade G-5, this material has comparable electrical properties.

Designation: G-8.

Size: $\frac{1}{16}$-in. thickness upwards.

Service: Has approximately comparable properties to NEMA grades GLCC-M or G-5; chemical-resistant; mechanical properties less directional than woven-base laminates; machines to smooth surface; flexural strength, 30,000 psi; impact strength, 7.0 ft-lb per in. notch edgewise-lengthwise, and 6.0 edgewise-crosswise; bonding strength, 1500 lb; dielectric strength, 45 kv parallel to laminations, 200 v per mil perpendicular to laminations; arc resistance, 130-180 sec; dissipation factor (D-24/33), 0.032; dielectric constant (D-24/23), 6.7; volume resistivity (C-96/35/90), 25,000; surface resistance (C-96/35/-90), 250; water absorption (24 hr), 2.00% for $\frac{1}{16}$-in., 1.75% for ⅛-in., 1.50% for ½-in.

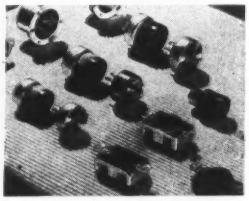
Design: Glass fiber mat impregnated with melamine resins.

For more data circle MD 43, Page 207

CAPS, CONNECTORS, RECEPTACLES 44

. . . lock to prevent accidental disconnection

Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford, Conn.



A simple twist of the cap in the connector body or receptacle locks the cap in position.

Designation: Hart-Lock.

Size: Dimensions of rubber caps, and Bakelite connectors and receptacles as follows;

		2-Wire	3-Wire	4-Wire
Cap:	diam (in.)	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{4}$
	height* (in.)	$1\frac{1}{16}$	$1\frac{13}{32}$	$1\frac{1}{2}$
	cord diam (in.)	0.296–0.625	0.437–0.750	0.437–0.750
Receptacle:	height† (in.)	$2\frac{3}{8}$	$3\frac{9}{32}$	$3\frac{9}{32}$
	width (in.)	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{31}{32}$
	depth (in.)	$1\frac{9}{32}$	$1\frac{9}{32}$	$1\frac{9}{32}$
Connector:	diam (in.)	$1\frac{23}{32}$	2	$2\frac{1}{4}$
	height§ (in.)	$2\frac{3}{32}$	$2\frac{17}{32}$	$2\frac{5}{16}$

*Including cord grip; excluding contacts. †Mounting hole center to center. §Including cord grip.

Service: 2-wire—for 20 amp, 250 v; 3-wire and 4-wire (polarized)—20 amp, 250 v ac or dc, or 10 amp, 575 v ac; prevent accidental interruption of electric service.

Design: Caps lock in connectors or receptacles by inserting and twisting; adjustable cord grips; rubber or armored caps; armored Bakelite connectors: Bakelite or porcelain receptacles with or without cover plates; motor plugs also available.

For more data circle MD 44, Page 207

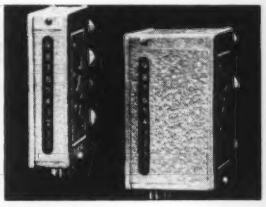
NEW PARTS

ELECTRONIC COUNTERS 45

. . . accept 1 million counts per second

Berkeley Scientific Corp., 2200 *Wright Ave., Richmond, Calif.*

One of these units can also resolve paired pulses separated by as little as 0.8-microsec.



Designation: 700A, 705A, 706A, 707A.

Size and Service: 5½ in. high, 5½ in. deep;

	700A	705A	706A	707A
Paired-pulse resolution (microsec)	5	5	1	0.8
Max counting rate (thousand cps)	40	100	350	1000
Width (in.)	1⅜	1⅜	2½	3¼
Weight (lb)	1	1	1 1/16	1½

Design: Electronic unit counts from 0 to 9, presenting illuminated numeral on front panel; 10th pulse resets counter to zero and simultaneously generates one pulse which may be applied to input of following counter or other device; one or more units may be reset to zero by momentarily opening grid return circuit; 700A and 705A utilize octal plug, 706A and 707A the 11-pin plug; can be cascaded indefinitely.

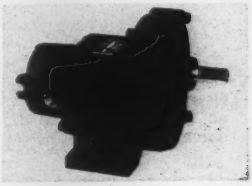
For more data circle MD 45, Page 207

TACHOMETER HEAD 47

. . . for rugged, very low speed service

Metron Instrument Co., 432 *Lincoln St., Denver 9, Colo.*

Built-in gearing permits direct measurement of speed of extruders, welders, kilns, conveyor belts, ovens, dryers, etc.



Designation: 57 M.

Size: 8 3/16 in. long with 1½ in. shaft extension, 5 1/16 in. wide, 6⅝ in. high; ¾-in. diam shaft; ½-in. pipe thread conduit.

Service: Measuring speeds from a fraction of an rpm to 199 rpm for full-scale indication; no damage from overspeeding of 2 to 10 times rated values; completely enclosed against dirt, abrasives and splashing liquids; electrical connections between head and speed indicator can be up to 1000 ft long; can be mounted in any position; permanently lubricated.

Design: Stainless steel head shaft, supported in large sealed ball bearings, drives tachometer unit through built-in gear reduction; anodized aluminum head casting with ⅜-in. wall and heavy mounting feet; conduit connection can be rotated to any one of 4 positions.

For more data circle MD 47, Page 207

CONTROL TIMERS 46

. . . feature unusual mounting versatility

General Control Co., 1200 *Soldiers Field Rd., Boston 34, Mass.*

Ranges from 6 millisec to 60 sec are available to control timed operations.

Designation and Size: 3⅜ in. dial;

Type	Face Size (in.)	Depth (in.)	Frame
ETB	4 x 6½	5 1/16	Back of panel or housing mounting
ETR	5 x 5½	...	Recessed or flush panel mounting
ETF	5 x 5½	...	Flanged for front mounting through panel hole
ETH	4½ x 8	4 7/16	Sheet-metal housing

Service: Controlling timed operations with control contacts either opening or closing at end of each timing period; ranges—0.06 to 1.2, 0.5 to 8, 0.75 to 15, 1.5 to 30, 3 to 60 sec; control contacts rated 10 amp at 125 v ac noninductive; operation from 115 or 220 v, 60 cycle ac.

Design: Discharge of a resistor-capacitor network through a sensitive gas tetrode relay tube provides basis for each timing period; double-pole, double-throw control contacts; timing range can be changed with plug-in condensers; timing period is set manually on potentiometer with indicator and external dial.

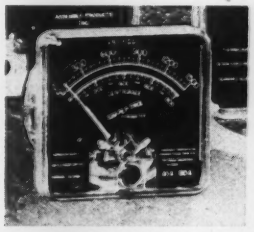
For more data circle MD 46, Page 207

BLACK FACE PYROMETERS 48

. . . in clear plastic cases

Assembly Products Inc., Main at Bell St., Chagrin Falls, O.

Three sizes are available and nine standard temperature ranges.



Designation and Size: 451, 4½ in. face; 351, 3¾ in.; 261, 2½ in.

Service: 9 standard temperature ranges from −200 to 3000 F, with corresponding Centigrade scales; automatic cold junction compensation with bimetal spiral on bottom torsion spring; corrected for copper error with variable permeability magnetic shunt across the poles of the magnet; medium-high sensitivity of 4 ohm per mv (222 ohm for 2500 F); case is dustproof, reasonably weathertight, and is free to breathe with changes in atmospheric pressure.

Design: Operate from any standard type of thermocouple, and are supplied with calibration for any type; clear plastic case with one-piece snap-on cover; for semiflush mounting in panels of nonmagnetic material (available for steel panels when specified); calibrating resistor is included to adjust meter to different length thermocouple leads.

For more data circle MD 48, Page 207

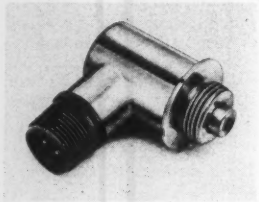
NEW PARTS

MINIATURE SOLENOID 49

. . . right-angle design for restricted space

Lafayette Engineering & Development Co., 9675 Santa Monica Blvd., Beverly Hills, Calif.

Connector is mounted at right angles to the solenoid centerline.



Size: 1⅜ in. high; weight, 0.29-lb.

Service: Provides 2 lb pull at ⅛-in. stroke; for 18 v dc; satisfactory for ambient temperatures to 300 F; designed to meet specification of MIL 4040.

Design: Side-mounted connector solenoid; variations in design available.

For more data circle MD 49, Page 207

TEFLON PLASTIC 51

. . . available in many sizes and forms

Ethylene Chemical Corp., 245 Broad St., Summit, N. J.

A number of new sizes and forms have been added to the company's line.

Size: Shaved tape, 0.002 to 0.060-in. thick; molded sheets, $\frac{1}{16}$ to 2 in. thick; molded round tubing, 1⅛ in. OD by ⅜-in. ID to 20 in. OD by 18¾ in. ID; beading, $\frac{3}{64}$-in. to 4.4 mm diam; extruded rod, $\frac{3}{16}$ to 1¼ in. diam; molded rod, 1⅜ to 6 in. diam.

Service: For machining or fabricating; chemically inert to all chemicals but molten alkalies and fluorine; stable from −320 to 500 F; resists erosion, moisture and weather; low coefficient of friction.

Design: Manufactured from DuPont Teflon (tetrafluorethylene resin).

For more data circle MD 51, Page 207

SMALL PLASTIC TUBING 50

. . . has 0.012-inch inside diameter

Irvington Varnish and Insulator Co., Fibron Div., 6 Argyle Terrace, Irvington 11, N. J.

All physical characteristics of regular tubing are maintained.

Size: 0.012-in. ID; 0.012-in. wall thickness.

Service: As insulation for miniature electric components; tensile strength, 3000 psi; minimum elongation at break, 300%; available in 2 materials with properties as follows;

	Temflex 105	Transflex
Low temperature (C)	−40	−50
Dry dielectric strength (v per mil)	1200	1000
Wet dielectric strength (v per mil)	1000	800
Water absorption (24 hr, %)	0.55	0.4
Power factor (%)	5.2	....
Dielectric constant	11.7	....

Design: Extruded in Temflex 105 (black, green, white, yellow, red or blue), or Transflex (transparent) plastic.

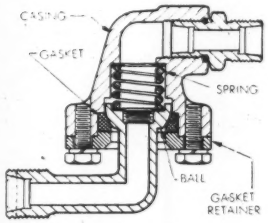
For more data circle MD 50, Page 207

SWIVEL JOINTS 52

. . . handle high-pressure hydraulic fluids

Barco Mfg. Co., Dept. J-18, 1801 Winnemac Ave., Chicago 40, Ill.

Self-aligning, these joints can be used at hydraulic pressures to 3000 psi.



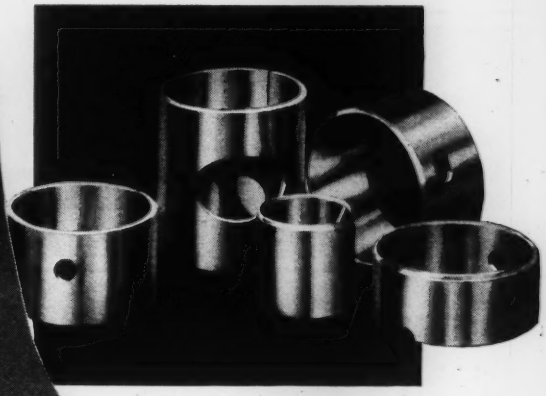
Size: For ¼, ⅜, ½ or ⅝-in. OD tubing (⅛, ¼, ⅜ and ½-in. standard pipe, respectively).

Service: Two types—(1) for hydraulic pressures to 3000 psi at temperatures from −80 F to 275 F, (2) for 2000 psi hydraulic or 600 psi saturated-steam or corrosive-vapor pressures at temperatures from −100 F to 500 F; 360 deg swivel action; 15 deg side flexibility, permitting axial deflection in any direction to compensate for misalignment and absorb vibration.

Design: Stainless-steel hemispherical face rotates on gasket mounted in aluminum casing; AN, industrial Ermeto or standard pipe threads; male adapters to convert female casing threads to male tubing connections available.

For more data circle MD 52, Page 207

JOHNSON Babbitt Lined SLEEVE BEARINGS FAVORED FOR many APPLICATIONS



Technical data sheets on babbitt-lined bearings will be sent free on request.

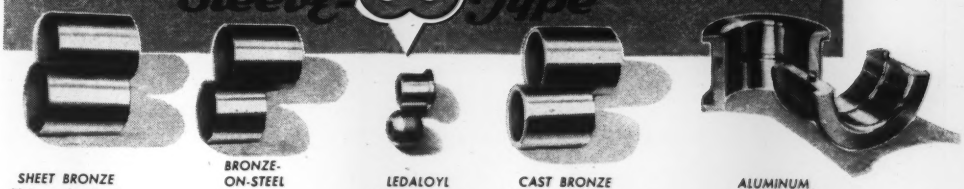
BECAUSE of the many inherent properties of babbitt as a bearing material, it fits into numerous applications. Babbitt provides a natural low coefficient of friction, easy conformability, high imbeddability, good wettability with lubricants, and high corrosion resistance to most oils. Coupled with these features, bronze or steel backing gives the necessary strength to the bearing. The alloy of lead-base or tin-base babbitt and the backing metal can be selected to meet operating conditions.

Through long years of research and experience, Johnson Bronze has developed a method of combining babbitt and either bronze or steel into a durable, lasting bond. This, together with the knowledge of the relative thicknesses of babbitt and backing for utmost efficiency and high quality workmanship, assure you of long, satisfactory service from Johnson Babbitt-Lined Bearings. Our engineers will gladly consult with you on proposed applications. Write for an appointment.

JOHNSON BRONZE COMPANY,
525 South Mill St., New Castle, Pa.

Sleeve Bearing Headquarters Since 1901

JOHNSON B BEARINGS
Sleeve-Type



SHEET BRONZE
Plain or graphited

BRONZE-ON-STEEL
Copper Alloy

LEDALOYL
Self-Lubricating

CAST BRONZE
Plain or graphited

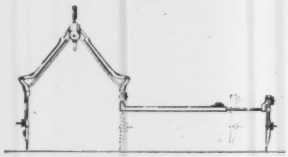
ALUMINUM ALLOY

EQUIPMENT

COMPASS 53

. . . features parallel opening legs

A. Partrick Co., 9 Grove St., Westwood, N. J.



Lower compass legs always stand perpendicular to drawing paper.

Size: For up to 9-in. diameter circles as bow compass, up to 26-in. diameter circles as beam compass.

Service: For ink or pencil drawing; legs can be locked in any position; for circles greater than 9 in. diameter lengthening bars are used.

Design: Linkage construction bow compass with telescopic lengthening bar; locking screw on head locks legs in any position; nickel silver.

For more data circle MD 53, Page 207

DRAFTING KIT 54

. . . has leather carrying case

Berger Scientific Supplies Inc., 342 Madison Ave., New York, N. Y.

New kit holds all necessary drafting instruments and supplies.

Size: 16 x 24 in.

Service: Convenient carrying or storing of tools and supplies for drafting jobs.

Design: Carrying case contains any one of 8 different types of drawing instrument sets plus protractor, architect's and engineer's scales, 8 and 10-in. triangles, French curve, draftsman's tape, pencil pointer, 2 drawing pencils and 2 erasers; two large inner compartments for drawing paper, notes, blueprints and other materials; scuff-resistant, water-resistant, simulated-leather case with slide-in handles.

For more data circle MD 54, Page 207

DRAFTING PENCIL 55

. . . has color code rings

V. & E. Mfg. Co., P.O. Box 950 M, Pasadena 20, Calif.

Lightweight and finely balanced, this holder has been designed to taper evenly to the point.

Designation: Vemco Tec.

Size: For 5¼ in. leads.

Service: Degree of hardness of lead being used is indicated by color code rings; takes 3B to 9H leads and color leads; chucking device holds lead evenly with no tendency to pinch off.

Design: Chuck for holding leads is concealed within holder body; made of durable lightweight materials.

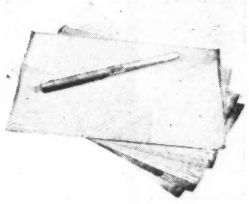
For more data circle MD 55, Page 207

PERSPECTIVE GRAPHS 56

. . . free from distortion

Tech-Art Graphs, 315 South 15 St., Philadelphia 2, Pa.

These graphs, based on visual perception principles, permit accurate perspective drawings.



Size: For drawing sizes from 8 x 10 in. to 30 x 60 in.

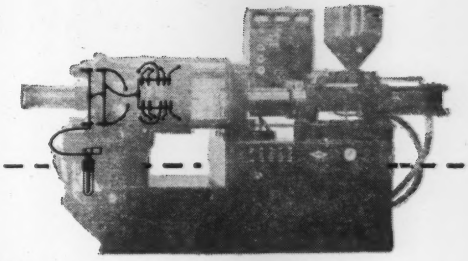
Service: Background grid for perspective drawings; set of seven basic graphs provides perspective grids at different angles, 30 x 30 deg, 15 x 45 deg, 45 x 15 deg, 5 x 55 deg, 55 x 5 deg, 7½ x 27½ deg, 27½ x 7½ deg; each graph may be used as top view or inverted as bottom view, allowing choice of 14 different views; dimensions may be plotted and projected from grid.

Design: Graphs represent inversion of the six faces of a cube; each of six planes is a grid graduated in true perspective foreshortening.

For more data circle MD 56, Page 207

Perfected!

...to eliminate hit or miss lubrication



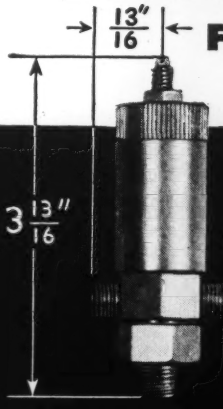
Alemite Type I Accumeter lubricates 14 main bearings simultaneously on this IMPCO Plastic Molding Machine.

ALEMITE Accumeter

REG. U. S. PAT. OFF.

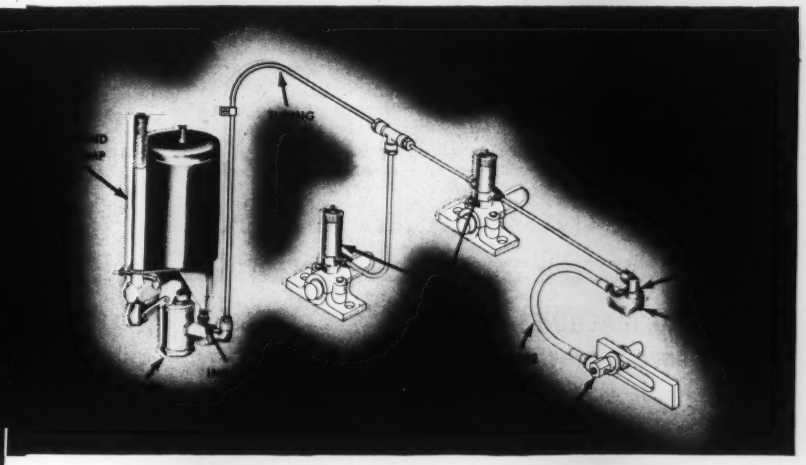
AUTOMATIC LUBRICATION

Fights Friction Automatically... From One Central Point... with No Bearings Missed!



Type I Accumeter Valve

For fluid oil or light grease. In three sizes, delivering from .005 to .050 cu. in. of lubricant. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation.



brings all these advantages!

- Eliminates shutdown time for lubrication. *Adds* productive time to machine output.
- Seals completely against dirt, grit, water all the way from "Barrel-to-Bearing."
- Prevents bearing troubles due to neglect or use of wrong lubricant.
- Services *all* bearings—including those inaccessible or dangerous—in one operation.
- Avoids work spoilage and bearing repairs due to over-lubrication.

Factory-Tested... Field-Proved! Exhaustive tests showed *no variation* in the amount of lubricant discharged . . . even after 73,312 lubrication cycles, *equal to 122 years of twice-a-day service.* Proved in the field, where one big-plant installation reduced lubrication costs $3,527 in only 65 days!

Make your machines produce more, last longer and cost less to run

From one central point, Alemite Accumeter Lubrication System delivers the exact, measured amount of oil or grease to *all* bearings of a machine. In seconds—in a fraction of the time required for hand lubrication—Accumeter *automatically* measures and delivers lubricant . . . while the machine keeps operating. No downtime for lubrication . . . no points missed.

Type I Accumeter is a single line system . . . easy to design, easy to build into *any* machine. Completely versatile—it can serve single machines or a group of machines, with semi-automatic or fully automatic lubrication.

Out of sight, out of reach or dangerously located bearings are no maintenance problem! They get safe, positive lubrication with the Accumeter Type I System. It is one of three which Alemite makes available to better serve designers' requirements.

SEND NOW for your free copy of this new Alemite Accumeter Catalog and Engineering Data Book. Address: Alemite, Dept. R-82, 1850 Diversey Parkway, Chicago 14, Ill.

A PRODUCT OF SW STEWART WARNER

ALEMITE

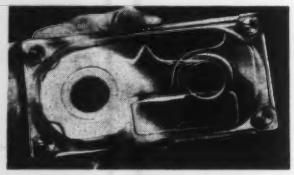
REG. U. S. PAT. OFF.

EQUIPMENT

MAGAZINE RECORDER 57

. . . reloads in 20 seconds

Alden Electronic and Impulse Recording Equipment Co., P.O. Box 125, Westboro, Mass.



Preloaded magazines interchange quickly, hold 8-day supply of special paper.

Size: $6\frac{7}{16}$ in. x $3\frac{3}{8}$ in. x $2\frac{5}{8}$ in.

Service: For monitoring and recording any type of intermittent data; provides permanent record on special Alfax paper strip; magazine can be sealed while recording and then sent intact to any point for interpreting; records two actions plus time action took place; connects with snap-action switch to monitored item; plugs into 110 v ac line.

Design: Magazine and driving unit; magazine is self-contained and has recording electrodes, timing switch and paper reels; driving unit contains synchronous motor, pinion gear to engage and drive one reel, 4 resistors, and a rectifier; resistors and rectifiers provide dc signal of few mils to mark the sensitive Alfax paper; signal circuits have test point jacks; magazine fastened to driving unit with target screws for rapid change; detachable line cord.

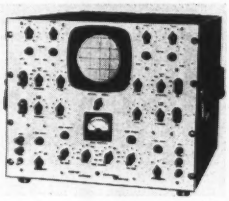
Application: Time and motion study; punch-press operation; current flow; stress and strain; computer operation.

For more data circle MD 57, Page 207

DUAL-CHANNEL OSCILLOSCOPE 59

. . . can be adapted to film recording

Electronic Tube Corp., 1200 East Mermaid Lane, Philadelphia 18, Pa.



Two independent signals are displayed on the face of single cathode ray tube.

Designation: H-21A.

Size: 21 in. wide, $16\frac{1}{2}$ in. high, $22\frac{1}{2}$ in. deep; 5-in. cathode ray tube; weight, 110 lb.

Service: Sweep circuits have range of 2 to 50,000 cps; both channel input signals can be observed on common or separate time bases; measurement up to 150 volts peak-to-peak.

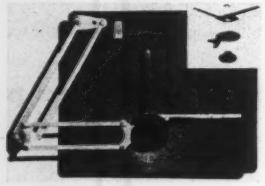
Design: Transfer switch permits interchange of deflection axes, readily adapts unit for film recording where film motion occurs in vertical plane; individual control of channels for intensity, focus and position of x and y axes; wide-band high-gain dc amplifiers provided on both horizontal and vertical axes; built-in direct-reading calibrator supplies 60 cycle square wave to vertical amplifiers; panel voltmeter indicates continuous calibration voltage; built-in attenuator governs range; cabinet or relay rack mounting.

For more data circle MD 59, Page 207

DRAFTING MACHINES 58

. . . have improved protractor construction

Drafting Equipment Co., Cochranton, Pa.



Interlock between clamping nut and protractor prevents disturbance of L-shaped integral scales.

Designation: Drafto 10-H, 15-H, 20-H, 20-WH, 20-U, 25-H and 25-CU.

Size: 10-H takes 9 x 12 in. sheet; 15-H takes 10 x 15 in. sheet; 20-H, 20-WH, 20-U take 12 x 18 in. sheets; 25-H, 25-CU for 18 x 24 in. sheets.

Service: Integral scales may be set to any angular position up to 90 deg each side of zero; protractor graduated to 2 deg for full 180 deg with extra graduations at 45 deg position; furnished with mechanical, architectural, engineering or metric scales; H models are portable, mounted to board, with integral paper clamps.

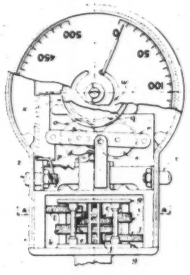
Design: L-shaped integral scales made in one piece; plastic knob locks and unlocks protractor; H models mounted on masonite board; WH models mounted on wood board; U and CU models are unmounted; 2 detachable scales supplied with all except 10-H and 15-H models; celluloid inking edges available.

For more data circle MD 58, Page 207

HAND TACHOMETERS 60

. . . have eddy-current drive

Equipoise Controls Inc., P.O. Box 269, Bronxville, N. Y.



Limit stop provides positive protection against temporary or accidental overrange.

Designation: A.T.H. 4, 6, 7 and 10.

Size: 3 in. diameter dial; carrying case, $7\frac{1}{4}$ in. x 4 in. x 2 in.; weight, 2 lb 2 oz.

Service: Accuracy of 0.5% at any speed; not affected by rapid acceleration;

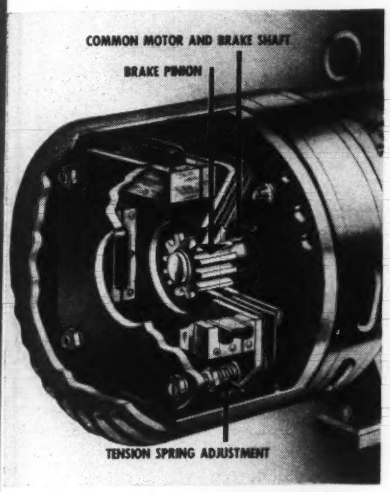
Type	Ranges (rpm)	Low Range Torque (oz-in.)
4	0/500, 0/5000, 0/50,000	0.75
6	0/400, 0/2000, 0/10,000	1.00
7	0/200, 0/2000, 0/20,000	2.00
10	0/1000, 0/5000	0.40

Design: Magnetic or eddy-current type; limit stop establishes fixed arc of travel for drag cup; revolving Alnico magnet; no mechanical connection between drag cup and magnet; when overranged, magnet revolves at faster speed inside cup and drag cup is held firmly against limit stop by higher induced magnetic torque; push-button pointer arrestor; supplied with rubber-tipped male and female centers, $3\frac{1}{2}$ in. extension, and hard rubber 6-in. circumference-measuring disk.

For more data circle MD 60, Page 207

Design Details Improve Brakemotor Performance

Efficiency of operation and long service life of integrally built disc brakemotors depends to a large degree on design details, according to Star-Kimble, which pioneered in the manufacture of this type of motor a quarter of a century ago.



Some of these design details, shown in this cutaway view of a Star-Kimble Brakemotor, are:

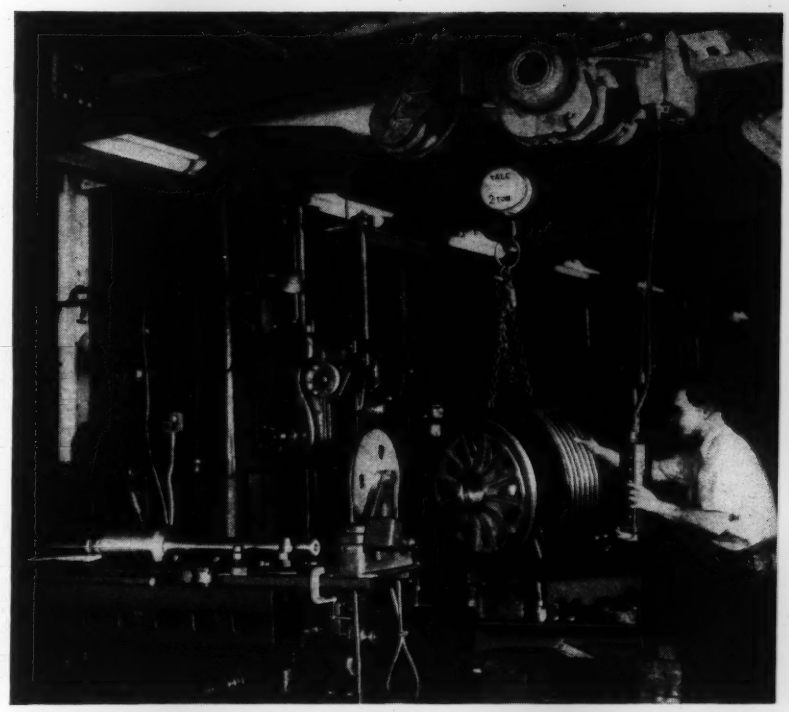
1. Brake pinion of C4140 moly steel, with a small diameter to cut brake inertia to a minimum. This feature results in quicker stopping of motor—1/5 to 1/2 second in average applications.
2. Convenient location of brake compression springs, permitting easy adjustment.
3. Short, sturdy common shaft for motor and brake, which virtually eliminates the danger of shaft breakage under torsion.

Unit Motor-and-Brake Design

This last feature is made possible by the fact that Star-Kimble Brakemotors are integral units, with motor and brake built together to work together—rather than a brake attached to a motor. Because of this fact, it is possible to design Star-Kimble Brakemotors to give the right combination of motor characteristics, braking torque and kinetic energy absorption for a wide range of service requirements.

The advantages of Star - Kimble Brakemotors have been demonstrated for many years not only in materials handling equipment, but in many other applications where fast, positive accurate stops are required.

Information on design ratings and features of these Brakemotors is contained in Bulletin B-501-A, available on request from Star-Kimble Motor Division of Miehle Printing Press and Manufacturing Co., 201 Bloomfield Avenue, Bloomfield, New Jersey.



HANDLING COSTS CUT by YALE CABLE KING HOISTS

— with Star-Kimble motors on hoist and trolley

ENTHUSIASTIC users of Yale Cable King Hoists report that fast, accurate, reliable handling of heavy loads result in substantial savings in time and costs.

Built for continuous service around the clock, and designed for operation outdoors as well as in, these hoists call for rugged components. Hence Yale & Towne turned to Star-Kimble for the hoist and trolley motors — and Star-Kimble engineers came up with special designs that meet every Cable King requirement.

The 3-phase squirrel-cage hoist motor operates under severe hoisting conditions without overheating — provides plenty of reserve capacity for short-time overloads. Dust-tight, weatherproof construction permits outdoor operation.

Trolley motor is a Star-Kimble Brakemotor that spots the load accurately — no need for time-consuming inching. Adjustable braking torque brings the load to quick, smooth stops.

This is typical of the many ways in which Star-Kimble engineering skill has benefited the designers and users of all sorts of motor-driven equipment.

For information on design and service features of Star-Kimble Squirrel-Cage Motors, write for Bulletin B-201; for Brakemotors, Bulletin B-501-A.

STAR-KIMBLE

MOTOR DIVISION
MIEHLE PRINTING PRESS AND MFG. CO.
201 Bloomfield Avenue Bloomfield, New Jersey

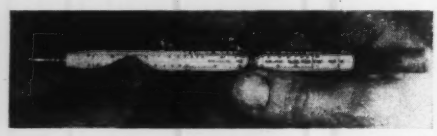
Advertisement

EQUIPMENT

POCKET SLIDE RULE 61

. . . combined with 2-color pencil

Device Development Co., 226 W. Fourth St., New York 14, N. Y.



Ten different functions are possible with this unique instrument.

Size: 6½ in. long; weight, 0.8-oz.

Service: For drawing or lettering, and calculating; has A, B, C, D, L, S, T, CM, and IN slide rule scales.

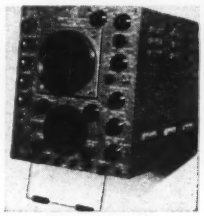
Design: Made of plastic, gold or nickel double-plated brass and steel; reading magnifier; telescopic measuring scale; depth gage, in. and cm; detachable straightedge; concealed eraser; plain and enlarging indicator for slide rule scales; clips to vest pocket; scales lettered with permanent marking process; selectively fitted and inspected parts; supplied with box and instruction folder.

For more data circle MD 61, Page 207

OSCILLOSCOPE 63

. . . for general-purpose laboratory work

Laboratory for Electronics Inc., 75 Pitts St., Boston 14, Mass.



High-gain, wide-band instrument is capable of quantitative measurements of high and low-speed electrical phenomena.

Designation: Model 401.

Size: 12½ in. wide, 15 in. high; 19 in. deep; weight, 55 lb.

Service: For quantitative studies of pulse wave forms, transients, and conventional signals of electronic circuits and equipment; amplifies dc to 10 mc signals; deflection sensitivity, 15 mv per cm deflection; response rise time, 0.035-microsec; signal delay, 0.25 microsec; sweep range, 0.01 sec per cm to 0.1 microsec per cm; delayed sweep range, continuously adjustable from 0-5000 microsec in 3 ranges; triggers, internal or external, + and −, 60 cycles, or delayed; power supply, 105-125 v or 210-250 v, 50-60 cycles, 400 w.

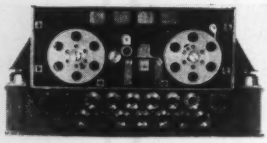
Design: High-gain two-channel amplifier; signal input line terminations; functionally colored control knobs; steel chassis in aluminum frame, folding stand; low capacity probe.

For more data circle MD 63, Page 207

LOW FREQUENCY RECORDER 62

. . . for vibration analysis

Davies Laboratories Inc., 4705 Queensbury Rd., Riverdale, Md.



This compact self-contained unit was designed for vibration studies in aircraft.

Designation: Model 501.

Size: 20⅝ in. wide, 10¾ in. high, 11¼ in. deep; weight, 55 lb.

Service: Input frequency range, 3 to 2000 cps for all channels; 12 channels for vibration pickup, one channel for engine tachometer connection; 1.0 v max input to 12 data channels, 50 v max input to tachometer channel; better than 1% linearity; sufficient tape for 2 min continuous recording; operated from remote control box; supply voltage, 22-28 v dc; current supply at 25 v input, 6.5 amp idle, 8 amp recording.

Design: Total of 14 channels record on 1¾-in. wide tape; one channel carries internally-generated timing wave; all inputs modulate frequency of high-frequency carrier which is then recorded; control box has meter showing tape available; individual plug-in frequency modulators; plug-in reference frequency generator; internal calibration signal; internal timer for recordings; supported in vibration mount; playback equipment, automatic wave analyzer available.

For more data circle MD 62, Page 207

NOISE METER 64

. . . in lightweight, pocket size

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Shaped to fit the hand, this battery-powered meter is lower in cost than standard size sound-level meters.

Designation: 1555-A Sound-Survey Meter.

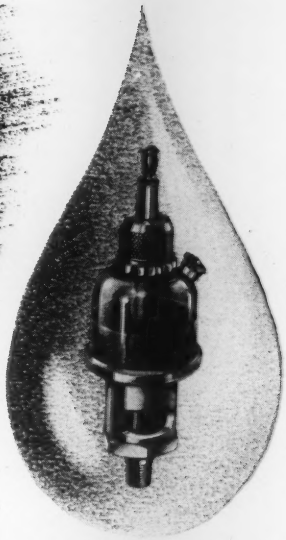
Size: 3⅛ in. long, 2½ in. wide, 6 in. high; weight, 1 lb 14 oz with batteries.

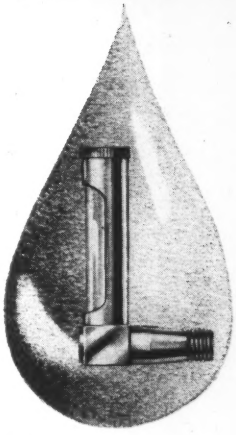
Service: For sound measurement not requiring the accuracy or versatility of standard size meters; sound-pressure-level range is 40 to 136 db on three frequency weighting networks, 85 db and above, 55-85 db, and 40-55 db; levels below 100 db given by sum of meter and attenuator readings; levels above 100 db given by sum of meter and attenuator readings plus 30 db; max safe operating temperature, 115 F.

Design: Consists of microphone, calibrated potentiometer, four-stage amplifier with weighting networks, indicating meter; weighting positions controlled by master switch; uses one 1½ v, size C flashlight battery, one 30 v hearing aid battery; aluminum, finished in black; mounts on tripod; leather carrying case available.

For more data circle MD 64, Page 207

For Lubricating Devices Call On GITS First!





GITS Bros. covers the *entire range* of lubricating devices: Oil Hole Covers, Oil Cups, Grease Cups, Bottle Oilers, Gauges. Gravity-Feed, Wick-Feed, Constant Level, Vibrating Rod styles. Threaded or Drive-type. Elbow or Straight.

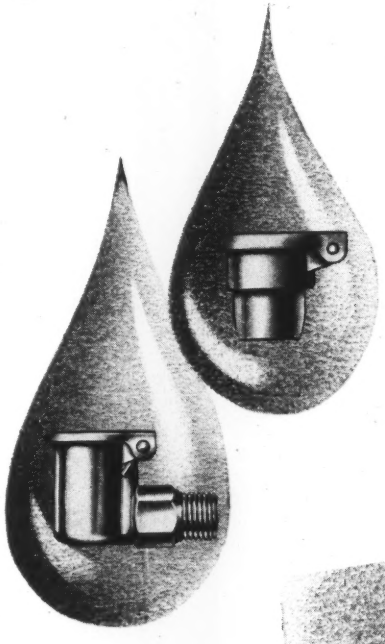
GITS Bros. offers the most complete selection of standard styles.

GITS consistent quality in design, materials and machining has made Gits Lubricating Devices the standard for industry for more than 40 years.

GITS Lubricating Devices are far-famed for solving tough oiling problems at low cost.

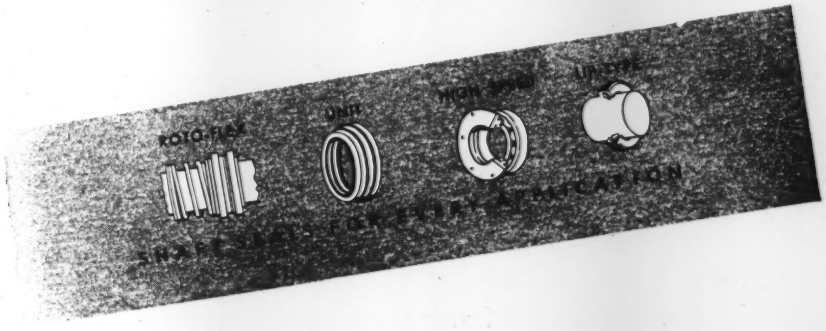
GITS Bros. Engineering Staff—true specialists in lubrication engineering—is at your disposal.

Write today for free Catalog No. 60-A. Use it as your handy reference for lubricating devices.



GITS BROS. MFG. CO.

1868 S. KILBOURN AVE. • CHICAGO 23, ILL.



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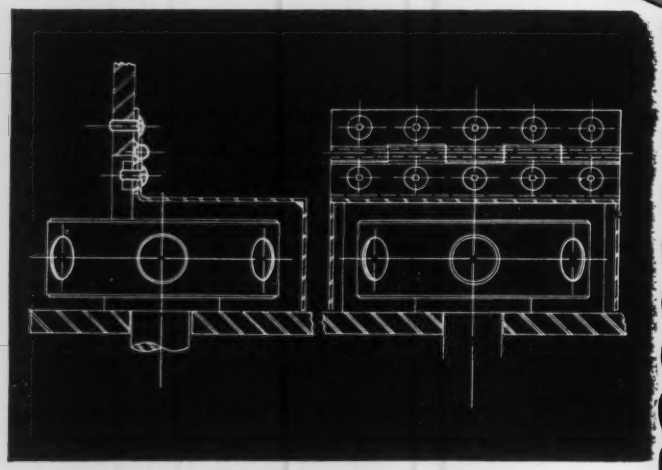
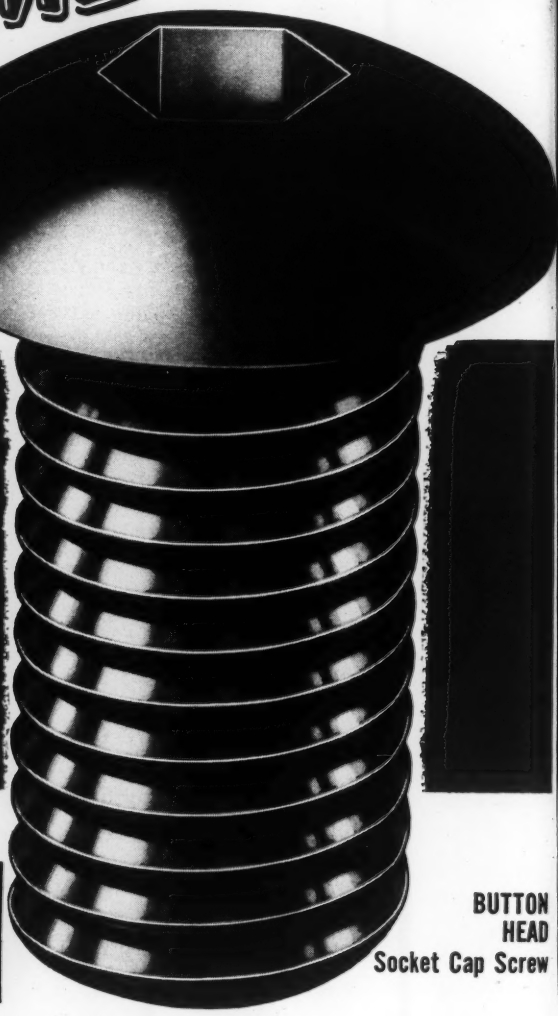
BUTTON HEADS





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Completely Cold Forged

SOCKET SCREWS

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THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN. U.S.A.

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

85. Instrument Bearings

General Motors Corp., New Departure Div.—24-page illustrated and comprehensive catalog AIB is devoted to small, precision instrument ball bearings. Of interest to designers, it deals with classification, design and operating requirements and includes application examples, descriptive details and dimensional data. Torque tests and testers are covered.

86. Motor Specifications

Century Electric Co.—Horsepower, revolutions per minute, voltages, dimensions and prices for wide range of models in line of squirrel-cage induction, wound-rotor induction, direct current, gear and single phase motors are presented in 4-page form 943 dated May 21, 1952. Types of controls are also covered.

87. Equivalent Chart-Calendar

Dayton Rogers Mfg. Co.—Here is a combination six-place decimal equivalent chart and calendar designed for wall hanging. Calendar period is July 1952-June 1953. Chart is broken down into 64ths and is printed in two colors.

88. Power Type Resistors

Ward Leonard Electric Co.—Seven distinct stock type resistors and various made-to-order types are described and illustrated in 64-page catalog No. 15. Resistor ratings range from 5 to 550 w, and resistance values are from 0.04 to 1.75 megohms. Terminal, mounting and enclosure details are given, and selection and application data are presented.

89. Aluminum Mill Products

Reynolds Metals Co.—1952 issue of illustrated 12-page brochure "Reynolds Aluminum-mill Products" outlines advantages of wrought aluminum alloys and contains an alloy selection guide. Material on fabricating and finishing and available literature is included.

90. Electrical Contacts

Gibson Electric Co.—Properties and uses of company's line of electrical contacts, made from fine silver, palladium, nickel, silver alloys and powdered metal compositions, are described in 12-page illustrated catalog C-520. It is designed to aid in selection and use of contacts in original equipment fields. Specifications and many applications are shown.

91. Instrument Sensing Units

Barber-Colman Co., Wheelco Instruments Div.—Application recommendations and prices on instrument sensing units and associated accessories are contained in illustrated 42-page Wheelco Data Book, 1952 edition. Included are data on making, checking, selecting and ordering thermocouples; wire sizes, resistances and temperature-millivolt curves. Also included in bulletin TC-9 are an index and specifications.

92. Set Screws

Set Screw & Mfg. Co.—Functioning as both catalog and reference book is a 20-page illustrated and descriptive bulletin on set screws of standard and self-locking types. Dimensions, prices, heads, points and materials are covered.

93. Photocopy Machine

American Photocopy Equipment Co.—12-page illustrated brochure gives you the principle of operation, various applications and general information on the Apeco Auto-Stat photocopying machine. Contact printer, timer and other accessories are mentioned.

94. Bellows-Type Seal

Gardan Mfg. Co. — Reciprocating shaft bearings can be protected from dirt by the bellow seal boot which retains the lubricant and introduces no added friction. Four-page illustrated folder lists specifications of stock sizes, much general information and prices.

95. Ball Bearings

Miniature Precision Bearings Inc.—Specifications on more than 120 different types and sizes of miniature ball bearings are found in 4-page illustrated catalog 52B. They are offered in three metals in diameters from 1/10 to 5/16-in. Design factors, lubrication, packing and engineering service available are covered.

96. Hollow Pin Conveyor Chain

Acmor Conveyor Chain Co.—Here, in 4 illustrated pages, you can get much valuable information on type HP hollow pin conveyor chain. Design features, what this chain can do for you and its outstanding attributes are outlined in bulletin No. HP-1.

97. Industrial Power Springs

Sandvik Steel, Inc., Sandsteel Spring Div.—Expressly prepared for use by engineers and designers, catalog data sheet deals with spiral, flat reverse tempered and cross curved flat springs. These springs are discussed with relation to their use in clock mechanisms, motion picture cameras, motors, office machines, recording devices, switches, timing devices, toys and vending machines.

98. Stainless Steel Fittings

Cooper Alloy Foundry Co.—11-page illustrated file folder on Quikupl stainless steel fitting for joining pipe or tube without threading or welding has photographs, cutaway views, cross-sections and specifications. Data on chemical resistance of coupling's Neoprene seal ring is also given.

99. Thread-Cutting Screws

Eaton Mfg. Co., Reliance Div.—4-page illustrated engineering data folder covers commonly used types of thread-cutting screws (Springtites and Sems) made for faster assembly work in sheet steel, die castings and plastics. Thread and point data on various sizes are given.

100. Hydraulic & Pneumatic Packings

Albert Trostel Packings, Ltd.—24-page illustrated catalog "Trostel Engineered Packings for Hydraulic and Pneumatic Application" presents general information and specific data on the various types of leather and synthetic packings. Research, development, design and testing facilities are covered. Series of 4-page data sheets give available sizes, prices and other information on specific types.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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101. Screw Machine Cams & Tools

American Cam Co.—Illustrated along with tabulated dimensions and prices in 12-page catalog 9 is line of cams and tools for automatic screw machines. Types covered include circular, flat forming and dovetail, end forming and standard circular form tools; cam, slotting bushing and circular tool blanks; and cam rollers and pins.

102. Bridge Spacer Fasteners

Prestole Corp.—Application and tabulated engineering information is presented in data sheet 215-A-5M on fasteners for spacer assemblies to aid proper selection of spacers for most any requirement. Use of spacers eliminates blind attachments and minimizes handling of parts and pieces.

103. Cylinder Applications

Hanna Engineering Works—"Cylinder Power in Action" is 6-page folder which illustrates 16 cylinder-powered movements and shows 21 actual application photos. Many of the Hanna hydraulic and pneumatic cylinders, as well as manually and electrically operated control valves are also shown.

104. Metallic & Plastic Packing

Durametallic Corp.—Described and illustrated in 4-page bulletin 443 is Handy-Pack, a combination of metallic and plastic packing for general sealing applications. Both lead foil type AB and aluminum foil type DD are covered. The Handy-Pack unit provides flexible, lubricated metallic and semimetallic spirals for average stuffing box requirements.

105. Welded Steel Tubing

NiKoh Tube Co.—Featured on back of 4-page folder No. 536 is chart of tabulated size tolerances for round welded mechanical tubing made from hot rolled carbon steel. Tubing can be made with tensile strengths as high as 102,000 psi.

106. Glossary of Terms

International Nickel Co.—Over 150 technical terms that are used in common between suppliers and users of ferrous and nonferrous castings are contained in 36-page "Glossary of Terms for Producers and Users of Iron Castings." Glossary should prove useful to the designer, engineer and purchaser of castings.

107. Stainless Steel Catalog

Armco Steel Corp.—Newly revised, 44-page comprehensive catalog PO 152 on stainless steels describes company's technical service and discusses the fundamentals of stainless steels, chromium nickel types, ferritic chromium, martensitic chromium and the new precipitation-hardening types. Properties of these steels are detailed. Selections on available products, as well as summaries on fabricating practices, blackening and electropolishing are included.

108. Rivets, Pins, Studs, Etc.

Brainard Rivet Co.—Cold-headed small rivets, pins, studs and specials are subject of 4-page illustrated bulletin entitled "Brainard Rivets." Economies of cold-heading, available finishes and application data are included.

109. Investment Castings

Precision Metalsmiths, Inc.—Step-by-step illustrations in 12-page illustrated booklet "Pour Yourself an Assembly" show how company has cast more than 160 different ferrous and nonferrous alloys by the precision investment process. Parts range in weight from a fraction of an ounce to more than 5 pounds.

110. Jan-R-11 Resistors

Stackpole Carbon Co.—JAN types of resistors including RC10, RC20, RC21, RC30, RC31, RC41 and RC42 are described in handy bulletin. This convenient guide to JAN-R-11 fixed composition resistors also includes prices.

111. Selenium Rectifier Units

Syntron Co.—4-page illustrated bulletin "Selenium Rectifier Power Conversion Units" gives design data on heavy capacity equipment for changing alternating to direct current. These packaged units rectify 125 to 550-v current and are available in capacities from 3/4 to 500 kw.

112. Metal Spinning

Roland Teiner Co.—"The Story of Metal Spinning" is a 20-page well-illustrated brochure that really tells the complete story of metal spinning, its technique and applications. Step-by-step drawings show how metal is formed by spinning. Typical uses are shown. Facilities of company to make production of custom spinnings from the smallest up to king-size are pictured and described.

113. Ground Test-Stands

U. S. Electrical Motors, Inc.—Featuring seven modifications of Aero test-stands, 8-page form 1749 tells how these units with variable speed can be used in testing magnetos, generators, alternators, hydraulic pumps, constant speed drives and actuators. Stands ranging from ¼ to 70 hp have outputs up to 15,000 rpm. Graphs show comparisons of variable speed systems, load ratings and relative speeds.

114. Thermostatic Bimetal Uses

W. M. Chace Co.—32-page booklet "Successful Applications of Chace Thermostatic Bimetal" is compact summary containing 18 uses of bimetal as the actuating element in temperature responsive devices, plus condensed engineering data for bimetal element design and selection. Thermostatic devices employing bimetal are shown, and reference is made to available facilities of company's engineering and research departments.

115. Vacuum Metallizing

F. J. Stokes Machine Co.—The use of vacuum metallizing to deposit pure metals, alloys or metal salts on surfaces is fully explained in 16-page illustrated bulletin "Vacuum Metallizing Today." Included are uses, materials and properties of vacuum metallized coatings, basic advantages, specifications of vacuum metallizing equipment and design and construction advantages.

116. Resistors, Rheostats, Switches

Ohmite Mfg. Co.—Illustrated stock catalog No. 24, descriptive of Ohmite line of vitreous-enamel rheostats, composition potentiometers and resistors, wire-wound resistors, tap switches, radio frequency plate chokes and power line chokes, is 20 pages long and contains complete size and price data.

117. Quick Detachable Couplers

Foster Mfg. Co.—Catalog No. and hose and thread sizes are contained in 12-page illustrated booklet on Chrome Sleeve quick detachable couplers for air, grease and oil applications. Drawings show installation setup for series 3 and 5 couplers. Reusable hose fittings, male and female adapters and swivel nut connections are covered as well.

118. Weldments & Castings

United Tool & Die Co., Acme Tank & Welding Div.—"The Facts About Weldments and Castings" is a 24-page illustrated treatise and gives basic information about steel plate fabrication. All factors relating to selection of castings or weldments are covered.

119. Ball Valve

Foxboro Co.—According to illustrated folder "The Foxboro Ball Valve" this ¼-in. control was developed expressly for meter manifold application. Its advantages of long life on liquid, gas and steam service under pressure to 3000 psi have led to its availability for all industry.

120. Hydraulic Pumps & Fluid Motors

Eastern Industries, Inc.—"Eastern Hydraulic Pumps and Fluid Motors" is title of 12-page illustrated bulletin 800. Performance data, selection information and ratings are given for several models. Installation and ordering data on 12 pumps are included in drawings. Also charted are six basic hydraulic circuits.

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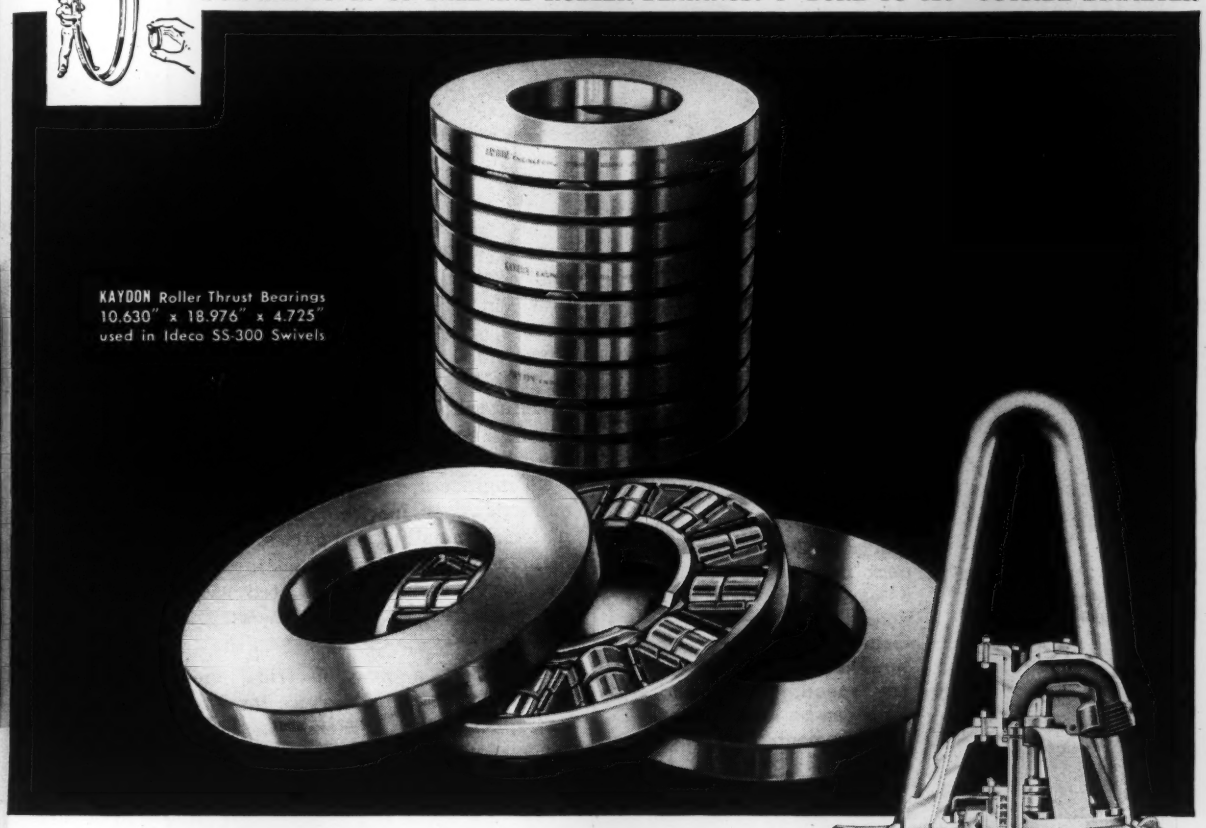
FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER



KAYDON Roller Thrust Bearings
10.630" x 18.976" x 4.725"
used in Ideco SS-300 Swivels

Takes 300-ton loads!

Dead-load capacities to 300 tons have been obtained, without added weight, in IDECO Streamlined Swivels for deep oil-well drilling. The success of these rotary swivels is the result of advanced engineering and years of experience in swivel manufacture. Rugged bearings are vital . . . husky **KAYDON** heavy-duty roller thrust bearings carry the full load.

In many other industries, machine designers find **KAYDON** bearings help make bigger machines possible, without unnecessary bulk and weight. If you have a bearing problem, contact **KAYDON** of Muskegon.

IDECO oil-well drilling Rotary Swivel made by IDECO Division, Dresser Equipment Company, (one of the Dresser Industries), Dallas, Texas, showing bearing location.

THE KAYDON ENGINEERING CORP.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

DESIGNING FOR DEFENSE?

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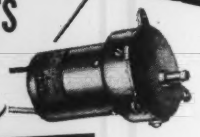
SYNCHRON TRADE MARK

TIMING MOTORS
TIMING MACHINES
CLOCK MOVEMENTS
D. C. MOTORS

TIMING MOTORS



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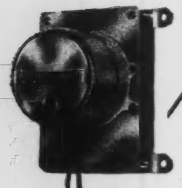
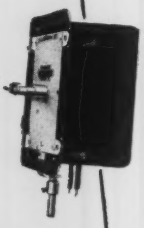


POWERFUL, PRECISE SYNCHRONOUS MOTORS

SYNCHRON synchronous motors meet your requirements for compact power. Pulls up to 8 oz. direct load continuously at 1 R.P.M. Gear trains can be furnished to convert to any speed. Unusual actions can be incorporated in movement. Our engineers will be glad to work with you in developing motors for special applications.

Hansen D. C. motors powered servo units which won Army-Navy E. Used also in aircraft instruments and radio control mechanisms.

TIMING MACHINES



CLOCK MOVEMENTS

Send NOW!

HANSEN
MANUFACTURING COMPANY INC.
PRINCETON, INDIANA

PLEASE SEND ENGINEERING DATA ON:

- ☐ SYNCHRON TIMING MOTORS
- ☐ SYNCHRON TIMING MACHINES
- ☐ SYNCHRON CLOCK MOVEMENTS
- ☐ MAGNA-TORC DIRECT CURRENT MOTORS

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MEN OF MACHINES

Formerly assistant to the vice president in charge of engineering, **J. C. Fink** has been appointed engineering manager of industrial products for Westinghouse Electric Corp., Pittsburgh. In his new position Mr. Fink will co-ordinate the engineering activities of all the industrial products divisions. Mr. Fink joined the Westinghouse graduate student course in 1927 and from 1928 to 1945 was a member of the marine and aviation section of the industry engineering department. He was then appointed manager of the general mill section of that department to supervise engineers engaged in applying electrical equipment to paper, machine tool, textile, rubber, food and materials handling industries. In 1948 he was named manager of the industry engineering department and the next year was appointed assistant to the vice president in charge of engineering.

♦

To direct a new electrical and mechanical engineering consulting service for machine builders and users, **Raymond T. Fenn** has been named chief engineer for Sterling Engineering Corp., Winsted, Conn.

♦

The Pfaudler Co. has announced the appointment of **Richard H. Starrett,** formerly development engineer, as chief engineer, of its Elyria, O., division. Previous to joining the Pfaulder Co. in 1948, Mr. Starrett spent several years as a consulting engineer in the rubber and plastics field, and before that served as a process engineer with the B. F. Goodrich Co.

♦

John J. Kleczka was recently assigned to the Norwood, O., works of Allis-Chalmers Mfg. Co., Milwaukee, as an assistant engineer.

♦

A. W. Kath was recently appointed president and general manager of the Kath Development and Mfg. Corp., Cleveland, a new subsidiary of Strong Cobb & Co. Inc. He will also serve as design and development engineer for the latter company. He was associated with Eli Lilley and Co. as manager of the machinery development department, and for more than 25 years was chief engineer of the Arthur Colton Co.

♦

S. H. Van Wambeck has joined the Hammarlund Mfg. Co. Inc., New York, as chief engineer. Mr. Van Wambeck, previously director of research and engineering for Knapp-Monarch Co., St. Louis, has served as director of a U. S. Army Signal Corps

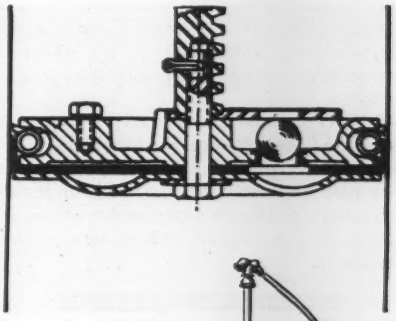
Are these two Cup Packings *Different*?

Yes... and HOW!

The leather cup packing on the left leaked gasoline. The *right* one *does not*.

A manufacturer of gallon stroke pumps for gasoline and oil dispensing employs a leather cup packing on the piston head as shown in the sectional drawing.

The ordinary cup leather did not deliver correct measure because of leakage through the leather. The complete pump assembly was shipped to G&K-INTERNATIONAL for suggestions. Because of the many thousands of pumps already in the field, redesign or improvement in the cup packing without change of the assembly was indicated.



and HOW! G&K-INTERNATIONAL developed a special leather treatment to completely prevent the passage of gasoline through the leather cup packing without changing its flexibility or other requisite characteristics. With these cups installed, the company now reports that the pumps deliver accurate measurement to their complete satisfaction.

Be sure you get the correct type of packing made from the proper components for your work! Send us complete specifications of your packings needs and G&K-INTERNATIONAL Engineers will help you solve your packings problems—before trouble starts.

second century G and K—INTERNATIONAL

GRATON AND KNIGHT ESTAB. 1851

Leather and synthetic packings

GRATON & KNIGHT COMPANY
Worcester 4, Mass.

IPC

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire

UNRETOUCHED PHOTO

High Pressure Hose Couplings

In design and performance, the patented BAR-WAY Streamlined High-Pressure Brass Hose coupling, standard equipment on all up-to-date fire apparatus, is the most practical and efficient ever marketed. The streamlined design eliminates obstructing projections. The full flow of the hose continues through the coupling . . . construction is sturdy, solid brass throughout . . . it is remountable so broken hose can be repaired on the job quickly and easily.

BAR-WAY couplings will easily withstand any pressure the hose will take; performance has been exceptional . . . tested for over 3,000 lb. pressure with a pull of over 500 lbs., without leakage, pulling away or showing any undue strain. In all tests, the hose has burst before any failure of the coupling.

BAR-WAY COUPLINGS FOR ALL HIGH PRESSURE HOSE LINES

BAR-WAY MFG. CO.
STAMFORD, CONN.

We invite inquiries on couplings for special applications. Send the attached coupon today.

BAR-WAY MFG. CO.,
60 Canal Street, Stamford, Conn.
Please send me further information regarding Bar-Way (Streamlined) Hose Couplings.
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Men of Machines

project, making studies of special radio receiving equipment. A former professor of electrical engineering at Washington University, St. Louis, where he received his B. S. and M. S. degrees in electrical engineering, Mr. Van Wambeck also instructed at both Oklahoma A & M and The Rice Institute. He is a member of the American Society for Engineering Education and the American Institute of Electrical Engineers and is a senior member of the Institute of Radio Engineers.

♦

Promotion of **G. Pierce Daiger** to assistant vice president-engineering of The Hoover Co., North Canton, O., was announced recently. Dr. Daiger succeeds **Donald G. Smellie,** formerly director of engineering, who is retiring after nearly 30 years with the company.

♦

Robert L. Brehm has been promoted to the position of assistant chief engineer of Snyder Tool & Engineering Co., Detroit, and its subsidiary, Arthur Colton Co. Mr. Brehm joined the Snyder engineering department in 1940 and had charge of electrical and hydraulic engineering for special purpose production machinery. In 1949, when Snyder purchased the Arthur Colton Co., he assumed similar engineering responsibilities in the re-engineering program which was set up for Colton products. He was given responsibility for the engineering of Colton mechanical and hydraulic presses for powder metal parts.

♦

George E. Prifold will head the LVT (Landing Vehicle, Tracked) division of the Ingersoll Products Div. of Borg-Warner Corp., Kalamazoo, Mich. He will be responsible for all engineering at the LVT plant, as well as testing at the company proving ground.

♦

Sundstrand Machine Tool Co., Rockford, Ill., has appointed **B. A. Gustafson,** manager of the machine tool division, as vice president of the company.

♦

Formerly resident engineer of National Seal Co., subsidiary of National Motor Bearing Co. Inc., at Van Wert, O., **Ezra Mosher** has been named chief research engineer of the parent company in Redwood City, Calif.

♦

Don Preston was recently named chief engineer of E. B. Wiggins Oil Tool Co. Inc., Los Angeles.

♦

Link-Belt Co., Chicago, has appointed **Robert W. Suman** chief engineer for its new Colmar, Pa., plant. **Norman Virkler** succeeds Mr. Suman as chief engineer for the Philadelphia plant. The Colmar plant, located north of Philadelphia, is now under construction and is scheduled to begin manufacturing operations later this year. Mr. Suman joined the company in 1934 and served at the Caldwell plant in Chicago before becoming chief engineer for power transmis-

Recently, The Consolidated Edison Company (in New York City) faced this problem: It had to produce a direct-process print from each one of more than ten thousand Brooklyn Underground Record Maps, showing the distribution system of electric service.

But satisfactory prints could not be produced directly from these maps. They were up to 30 years old . . . had been referred to constantly . . . and as a result were soiled, stained, creased, and "dog-eared."

What to do? Retracing was out of the question, since it would take a draftsman from two to three days to trace and check just one of these 17″ x 25″ drawings.

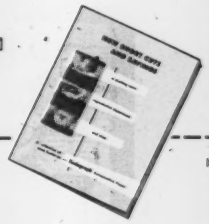
Kodagraph Autopositive Paper was the speedy, economical solution

With this revolutionary photographic intermediate paper, approximately 40 sharp and clean "duplicate originals" could be turned out in an hour. *Yes, 40 in an hour* because Kodagraph Autopositive Paper produces positive copies directly—without a negative step, without darkroom handling. At the same time, it drops out stains, creases . . . cleans up backgrounds . . . transforms weak detail into dense photographic black lines. Furthermore, Autopositive Paper can be exposed in standard print-making equipment . . . and processed in standard photographic solutions.

Thus, Consolidated Edison obtained—*in record time and at minimum cost*—a complete set of duplicate originals, which were used to produce the required direct-process prints . . . and were then filed away for future reference work and print-making needs.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction



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EASTMAN KODAK COMPANY
Industrial Photographic Division, Rochester 4, N. Y.

Gentlemen: Please send me a copy of "New Short Cuts and Savings"... describing the many savings Kodagraph Autopositive Paper is bringing to industry.

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sion products at the Philadelphia plant in 1946. For the past year he has been chief engineer for the Philadelphia plant, with responsibility for materials handling and power transmission engineering. Mr. Virkler has been associated with the Philadelphia plant since 1917. From 1946 to the present time he has been in charge of all enclosed-drive development work.

♦

Recently named vice president, **Carl C. Nelson** will be in charge of manufacturing and engineering of Meletron Corp., Los Angeles. Mr. Nelson was previously associated with Westinghouse Electric Corp. as a design engineer and as vice president and director of Electrical Machinery Mfg. Co.

♦

E. G. Bailey, founder and president of the Bailey Meter Co. and director and consultant of Babcock & Wilcox Co., was presented with the Distinguished Service Award of Ohio State University during commencement exercises last June.

♦

Appointment of **H. A. Martin** as engineering and production director has been announced by Caldwell Industries Inc., Kent, O. From 1947 to 1950 Mr. Martin was associated with the company as production manager. Since 1950 he has been affiliated with Clark Cable Corp., Cleveland.

♦

Archer W. Richards has been elected executive vice president of Designers for Industry Inc., Cleveland. He assumes direction of both commercial and government work. The company has also announced the appointment of **Arch B. Gardner** as a senior project designer.

♦

The first award of the K. C. Li Medal for meritorious achievement in advancing the science of tungsten was made to **William David Coolidge** "for his conception and development of a method for obtaining ductile metallic tungsten to the benefit of all mankind." Dr. Coolidge is director emeritus of the General Electric Research Laboratory in Schenectady and X-ray consultant to the company. To be awarded every two years, the award was established in 1948 by K. C. Li, who discovered tungsten in China.

♦

Fischer and Associates, Cleveland consulting engineers, recently appointed **Walter R. Rourke** as vice president in charge of engineering. Concurrently, the firm announced the opening of new offices at 5209 Euclid Ave.

♦

Promotion of two managers in the Buffalo Motor and Control division of the Westinghouse Electric Corp., Pittsburgh, has been announced. **Frank P. Taugher,** former manager of the industrial control engineering department, has been appointed to the newly created position of assistant to the vice president. Replacing Mr. Taugher is **D. L. Pierce,** former manager of the department's general purpose division.

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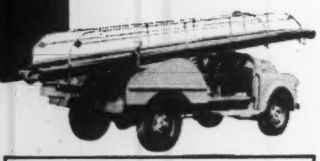

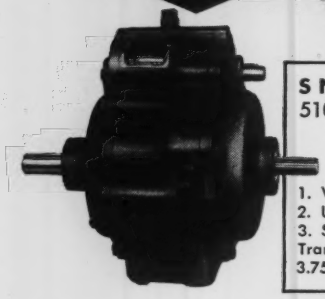

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Men of Machines

Westinghouse also recently named **James M. Wallace,** who had been manager of the switchgear distribution apparatus department, as manager of the Meter division. He succeeds **G. H. Grossnickel,** who has been appointed manager of manufacturing.

♦

Nathaniel Little and **Earl King** recently joined the staff of design engineers of The Standard Machinery Co., Mystic, Conn.

♦

Manager of The Dow Chemical Company's plastics department since 1945, **R. H. Boundy** has been appointed head of the company's research activities.

♦

Karl B. McEachron, General Electric engineer and authority on lightning, received the 1952 award of the Engineering Societies of New England. The citation described Dr. McEachron as "an electrical engineer who has won new laurels for his country as a pioneer in the understanding of and control of natural lightning."

♦

F. J. Stokes Machine Co., Philadelphia, recently appointed **Richard V. D. Strong** to the post of chief engineer.

♦

Paul Vinson and **Bernard E. Logsdon** have been appointed director of engineering and research and assistant chief engineer, respectively, by Sheldrick Mfg. Co., Upper Sandusky, O.

♦

Included among recent changes in the company's executive staff is the election of **Frank H. Driggs** as president of Fansteel Metallurgical Corp., North Chicago, Ill., and its subsidiary, Weiger Weed & Co. Dr. Driggs came to Fansteel in 1934 as director of research, was elected vice president in charge of technical development in 1938 and became executive vice president in January of this year. **R. Winchester** succeeds Dr. Driggs, with the title of director of technical division, which includes research, control laboratories and experimental engineering. He has been a member of the company's technical staff since 1937.

♦

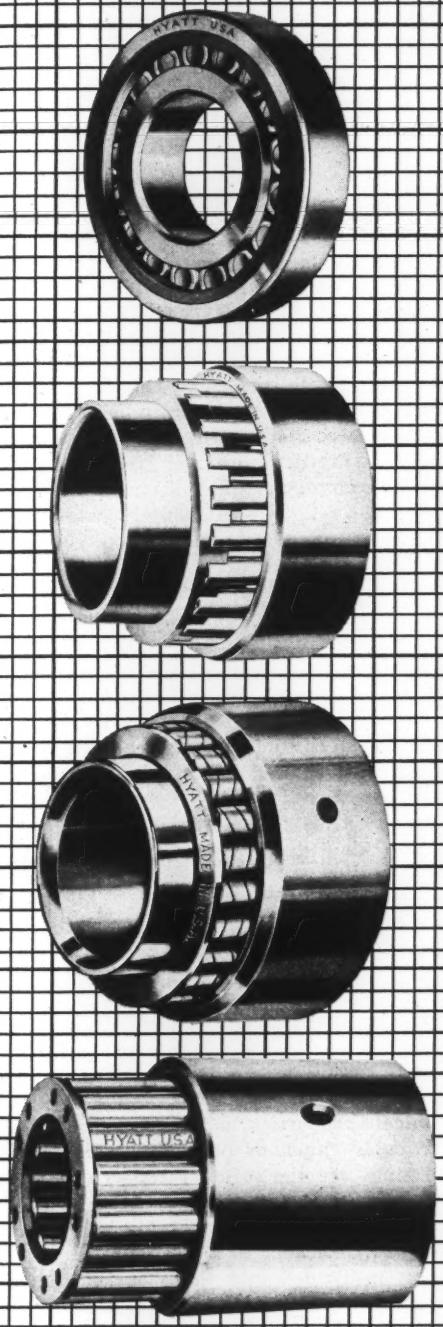
Ernest J. Klimczak has been appointed chief engineer, secretary, and member of the board of directors of Ahlberg Bearing Co., Chicago. He joined the company nine years ago as a tool engineer and was named assistant chief engineer several years later.

♦

New director of research and development at Norton Co., Worcester, Mass., is **Wallace L. Howe.**

♦

Rockwell Mfg. Co., Pittsburgh, has appointed **Charles C. Reiff** as chief engineer of its Barberton division, Barberton, O. **Bernard Last** succeeds Mr. Reiff as project engineer of the lubrication department and will be located at the home office.



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Practical Industrial Electronics

By F. A. Annett, associate editor, Power; *published by the McGraw-Hill Book Co., New York; 381 pages, 6 by 9 inches, clothbound; available through* MACHINE DESIGN, *$5.50 postpaid.*

Fundamental in its treatment, this book is the outgrowth of a series of articles on industrial electronic devices. It was written especially for engineers and electricians having little previous training in the subject. The introductory chapter discusses the nature of electrons and is followed by chapters on electron and photoelectric tubes. Succeeding chapters deal with: reactors and capacitors; electron-tube, mercury-arc, and disk-type rectifiers; electronic relays; amplifiers; voltage regulating devices; oscillators; photoelectric devices; combustion control and smoke indicating devices; magnetic-drive control; and motor and generator exciters. In the concluding chapters various types of electric motor, liquid level, pump, and heating system controls are analyzed. Simplified circuit diagrams are used extensively to aid in mastering the material.

□ □ □

Engineering Materials

By Joseph Marin, professor of engineering mechanics, Pennsylvania State College; published by Prentice-Hall Inc., New York; 491 pages, 5½ by 8½ inches, clothbound; available through MACHINE DESIGN, *$8.70 postpaid.*

Mechanical properties of engineering materials, with particular emphasis on their application to design problems, are the primary concern of this textbook. An analytical approach has been used and descriptive material on manufacturing and fabricating processes has been kept to a minimum.

The text is divided into three parts: general mechanical properties, specific materials, and materials testing machines and strain gages. In the general treatment of mechanical properties, static tension, compression, shear, bending, and combined stress properties are considered first. Fatigue loading is taken up next followed by chapters on impact and high and low temperature conditions. In the second part there are chapters on: structure of materials and control of properties; ferrous and nonferrous metals and alloys; and nonmetallic materials. The concluding part discusses the more important testing machines and strain gages that are used for determining me-

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By **Russell M. Roberts,** Chief Engineer,
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Fig. 4—All Welded Steel Frame *for the Parks Woodworking Machine Co., Cincinnati, Ohio. Sides are brake formed from 12 gauge metal.*

Fig. 3—Simple Jig *for welding square steel tubing components consists of clamps and locating pads.*

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Fig. 1—Original Construction— *Machine bracket formerly weighed 56 pounds, was difficult to cast, high cost incurred from excessive rejects.*

Fig. 2—Welded Steel Design *is stronger, more rigid yet weighs only 35 pounds. Weldment costs 33% less than original casting. Eliminates considerable time in machining and assembly.*

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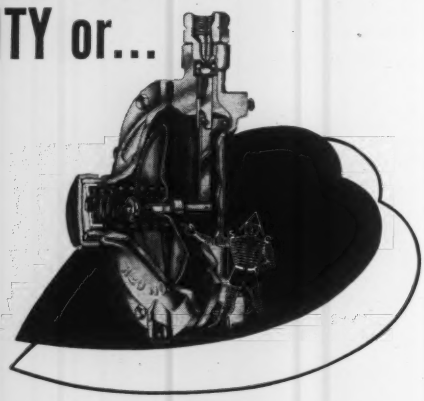

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chanical properties. Well illustrated, the book includes bibliographies and sample problems.

□ □ □

Copyright, Design and Patent Guide

By Henry J. E. Metzler, registered patent attorney; published by Ameliorant Co. Inc., Halesite, N. Y.; 125 *pages,* 5½ *by* 8½ *inches, leatherette bound; available from* MACHINE DESIGN; $2.00 *postpaid.*

In condensed form this book discusses the what, why, and wherefore of copyrights and patents. Written for the layman, its purpose, as the author explains, is "to outline the basic principles of the present copyright and patent laws, and to render assistance and helpful suggestions to those who seek protection for their intellectual property." The primary subject divisions of the text are: copyrights, design patents, and patents other than design patents. For each division the book deals with who and what can be protected; how to obtain protection; rights and abuses; infringements and remedies; and international considerations. Legal pitfalls are pointed out and explained. In addition, a comprehensive topical index for quick reference has been included.

Government Publication

NACA Technical Series: Each of these reports is 8 by 10½ inches in size, paper-bound and side-stapled, and contains complete drawings and illustrations. The following Technical Notes are available:

2589. *An Analytical Investigation Using Aerodynamic Limitations of Several Designs of High Stage Pressure Ratio Multistage Compressors*—56 pages

2593. *Design of Two-Dimensional Channels with Prescribed Velocity Distributions Along the Channel Walls. I—Relaxation Solutions*—69 pages

2598. *A Technique Applicable to the Aerodynamic Design of Inducer-Type Multistage Axial-Flow Compressors*—62 pages

2612. *Stress Problems in Pressurized Cabins*—91 pages

2617. *Relative Importance of Various Sources of Defect-Producing Hydrogen Introduced into Steel During Application of Vitreous Coatings*—31 pages

2618. *Creep in Metals*—52 pages: phases of an investigation of the fundamentals of creep in metals

Copies of these reports may be obtained from the National Advisory Committee for Aeronautics, 1924 F. St., Washington 25, D. C.

New Standards

Round Head Bolts—ASA B 18.5-1952: Carriage, button-head, step and countersunk bolts are covered in this revised standard which has been expanded to provide complete product specifications. Depth of

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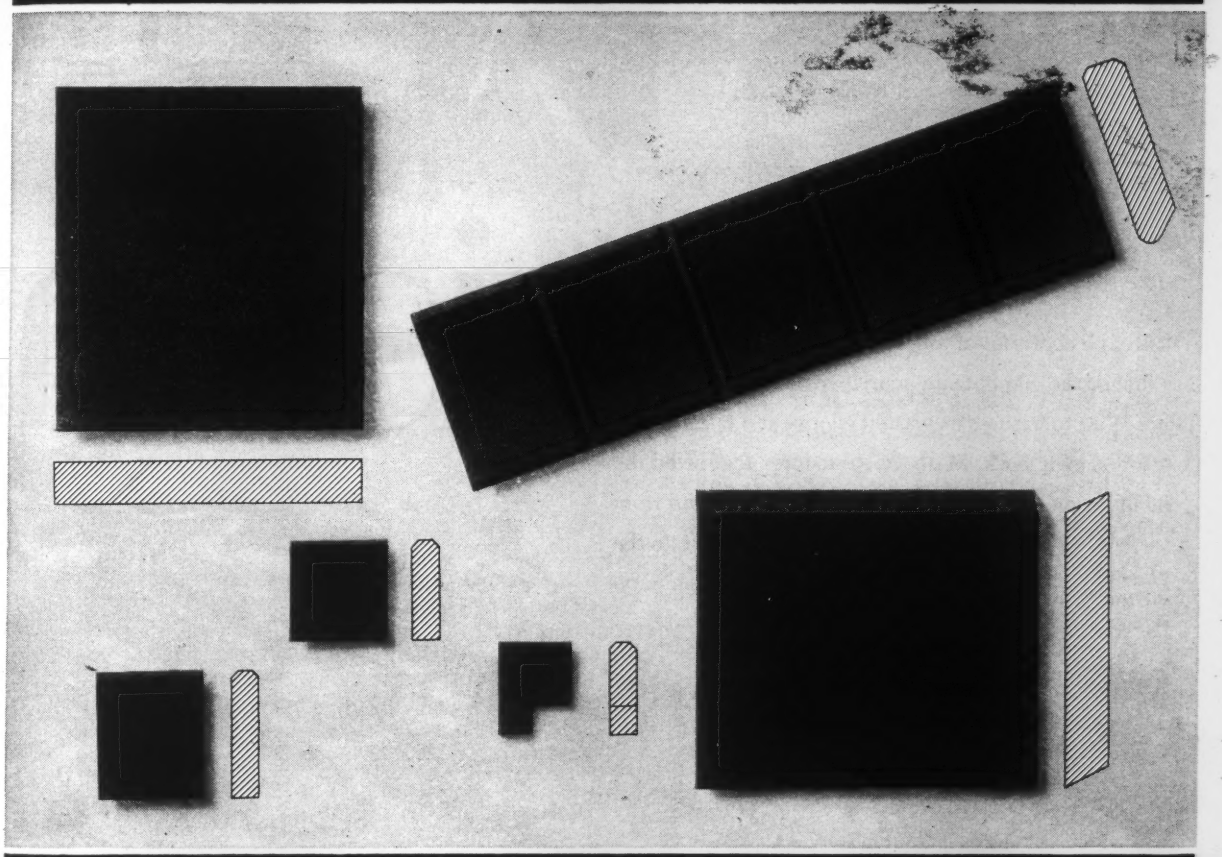

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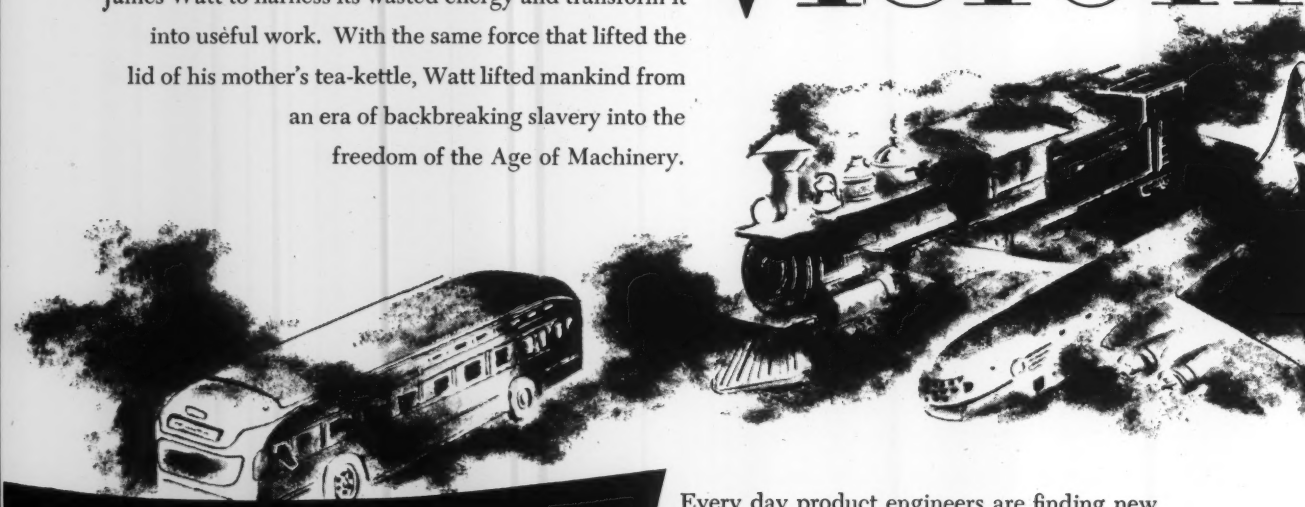

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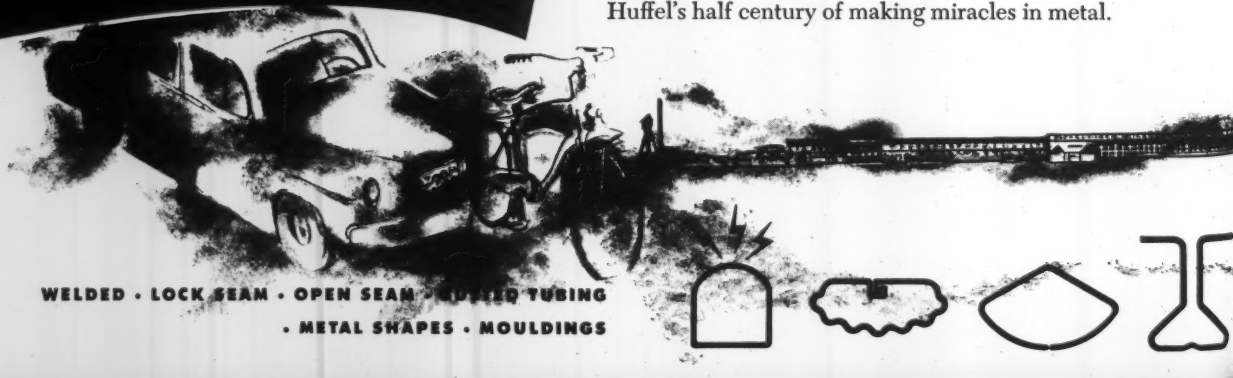

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square of ordinary carriage bolts has been changed to use the limits previously applying to short lengths. Mutilation and cracking that often resulted from the use of the longer depth of square has thus been eliminated. Additions to this standard include elevator bolts, T-head bolts and short-neck carriage bolts. Copies of this 15-page standard are available from the American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

Nonmetallic Gaskets for Pipe Flanges — ASA B16.21-1951: Extensive field research and user surveys by the Standards and Specifications Committee of the Mechanical Packing Association have gone into the development of this standard which covers gaskets for flanged pipe joints except cast iron pipe. Specifications are given for: types and sizes; material; dimensions and tolerances; and formulas for determining diameters. A table of dimensions, arranged to facilitate the selection of a proper gasket for the flange material, rating and type of facing used, has been provided. Five pages in length, copies of the standard are available for $1.00 each from the American Society of Mechanical Engineers.

Manufacturer's Publication

The Science of Precision Measurement: Dimensional quality control is the theme of this well illustrated, 256-page book, which deals with the methods and techniques of precision gaging and calibrating. Introductory chapters cover historical background and the meaning of clearance and tolerance. Succeeding chapters take up techniques and methods of precision measurement for dimensional control of products; devices discussed are: precision gage blocks, sine bars, optical flats and electric comparators. In the concluding chapter statistical systems of quality control are explained. Copies of this leatherette-bound, 6 by 9 inch book are available for $3.50 each from the DoALL Co., Des Plaines, Ill.

Association Publication

Steel Products Manual; Carbon Steel Wire: A revision of the 1949 issue, this paper-bound booklet contains Section 16 of the series of 30 manual sections dealing with major steel products. Metallurgical aspects of wire production are presented first, followed by a coverage of manufacturing practices. Commodity descriptions of coarse and fine round wire are presented next and constitute approximately half of the text. Concluding sections are devoted to commonly used methods for testing and evaluating wire, chemical requirements of steels, and tables of wire gages and other data. The booklet is 6 by 9 inches in size and contains 204 pages. Copies are available for 25 cents each from the American Iron and Steel Institute, 350 Fifth Ave., New York 1, N. Y.

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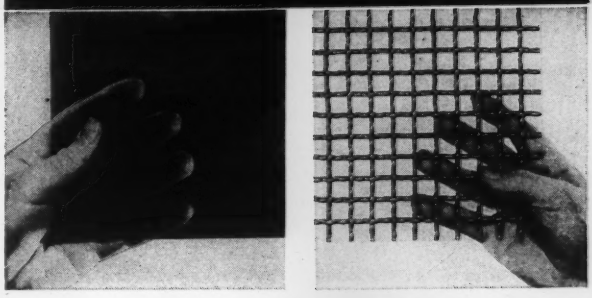

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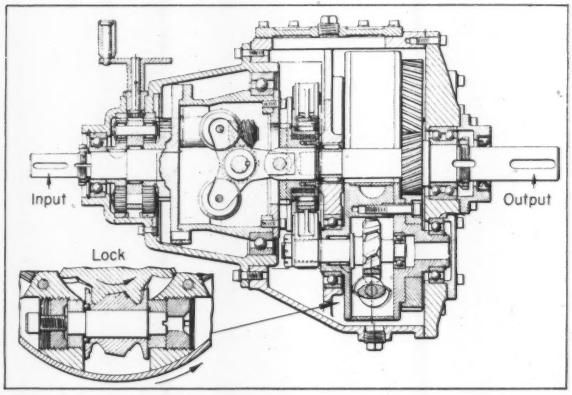
RATCHETING DRIVE through self-locking worm gears in an all-mechanical speed reducer provides infinite output speed control from zero to maximum. Each of three ratchet stages is oscillated through a splined lever linked to a spider carried on an adjustable eccentric driven by the input shaft. Roots and crests of the gear teeth and worm threads, respectively, are tapered so as to wedge in one direction. The tooth helix angle is such that oscillation of the gears in the other direction will rotate the worms



freely within the ratchet cages. Gears on each cage meshed with a pinion on the output shaft sucessively impart rotation to the output shaft as the units alternately lock and reset. Flyball weights balance the crank mechanism in compensation for eccentric positioning of the crank and spider assembly. Output power flow is said to be substantially free from impulses, and speed changes are made readily by simple handwheel adjustment. Patent 2,579,085 assigned to the Connecticut Variable Gear Corp. by Porter S. Morgan.

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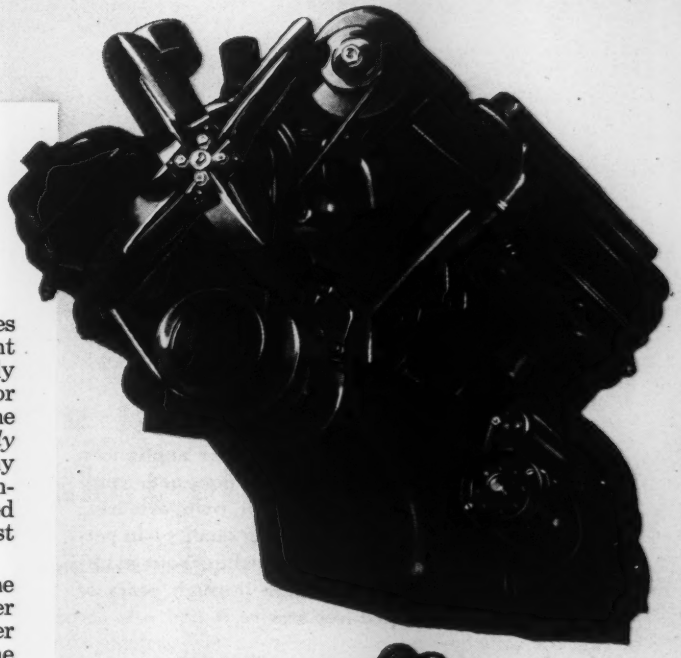
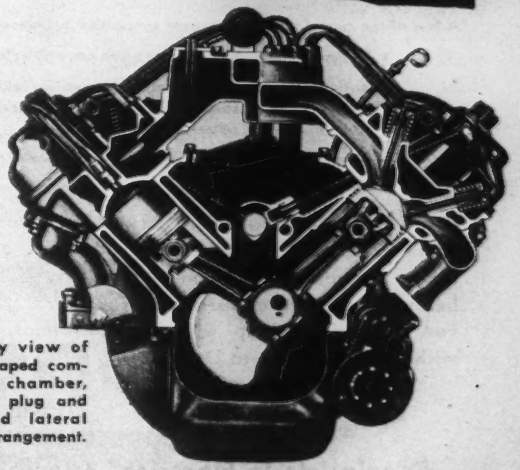




Cutaway view of dome-shaped combustion chamber, centered plug and overhead lateral valve arrangement.

Here's why . . . The great new Chrysler V-8 Industrial Engine is completely new in V-8 design. This engine embodies more desirable characteristics than ever before offered to Industrial engine users.

Hemispherical Combustion Chamber provides 33 per cent more horsepower, 16 per cent higher torque. It increases displacement only 3.2 per cent,* yet develops more power for displacement than any comparable engine in Industrial use. *It is today's most nearly perfect combustion chamber!* It allowed many desirable changes in V-8 design—most important of which are larger and wider spaced valves and "free-flow" intake and exhaust porting.

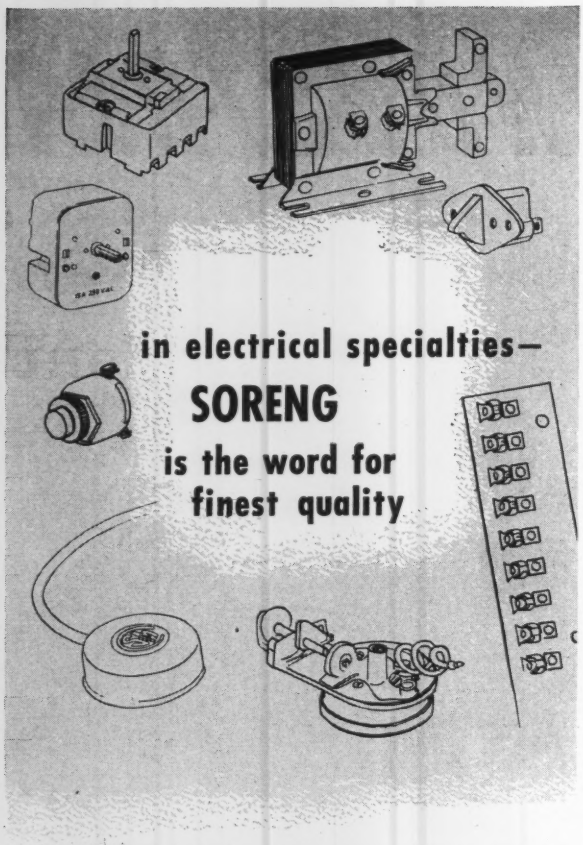
Centered Spark Plugs provide shorter flame travel through fuel. You get greater power from the same amount of fuel; easier, faster starting, *plus* less carbon deposit in the chamber, adding years to engine life.

Overhead Lateral Valves are larger, wider spaced. They operate cooler, eliminating pre-ignition. This ingenious valve arrangement permits gravity flow of the fuel and air mixture into intake and out of exhaust ports—practically eliminates back pressure.

More Efficient Cooling is due to less heat rejection in the combustion chamber. More heat is turned to power. More coolant flows around valves and bore. Water jacket completely surrounds cylinder. With *less coolant* this new engine *has better cooling* —a more compact, efficient, over-all cooling system!

These are only a few of the important developments made in Chrysler Industrial V-8's. There are many more. *These* engines will give you a whole new conception of Industrial power. Ask a Chrysler Industrial Engine Dealer to explain their advantages on your jobs, or write us direct for full information. **Marine and Industrial Engine Division, Chrysler Corporation, 12200 E. Jefferson Ave., Detroit 31, Michigan.** *Model IND-20

CHRYSLER
Industrial V Engines



Soreng electrical specialties for appliances, machines and other equipment are designed, engineered and built completely in our own extensive plants. That's your assurance of *finest* quality—in performance, in materials, in workmanship. Your assurance, too, of complete satisfaction through years of efficient, low-cost, trouble-free service.

A few of the *many* Soreng-engineered specialties include:—

- **TT Type Solenoids—for more work per unit volume.**
- **Switches—hundreds of various types for automobiles, refrigerators, washers, other home appliances, machine tools, and many others.**
- **Terminals—in a wide range of types that speed production and cut costs.**

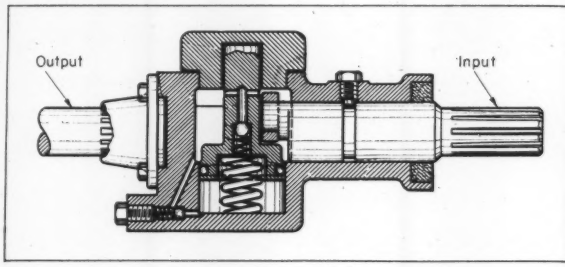
Every Soreng component is backed by more than 25 years experience, engineering leadership, and precision manufacturing. You can depend on Soreng because *Soreng means finest quality electrical specialties!* For engineering help with *your* problems, write—without obligation—to Dept. C28.

SM

Specialists In Electrical Specialties

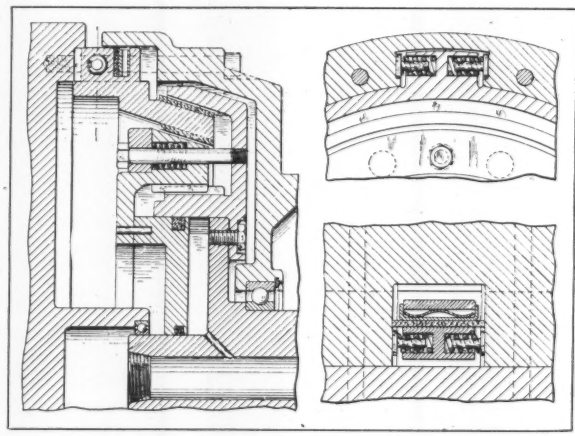
SORENG MANUFACTURING CORPORATION
9555 Soreng Ave., Schiller Park, Ill. (Chicago Suburb)
Plants: Schiller Park, Ill. • Fremont, Ohio

Noteworthy Patents



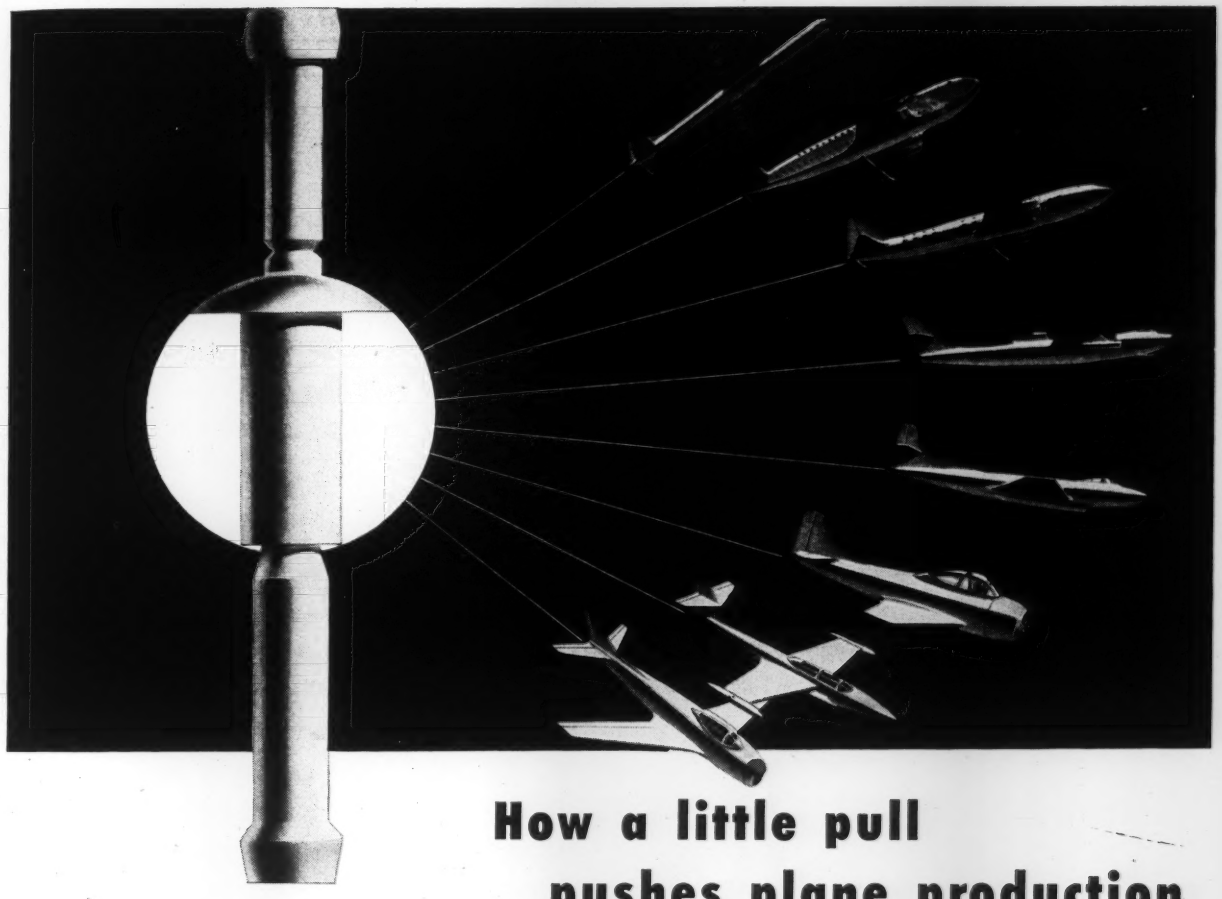
inder is refilled through a check valve built into the piston. Patent 2,575,475 assigned to Minneapolis Moline by Robert E. Stutzke.

FLOATING DOUBLE CONE in a marine reverse gear clutch provides cushioned engagement and damps engine vibrations within itself. Flywheel piloted, the internal-external lined cone receives torque through multiple spring-loaded plungers in engagement with lugs on the flywheel. Axial friction inserts carried between the driving lugs and held against the driven lugs under pressure of wave springs pro-



hibit free spring oscillation and damp vibratory movement of the lined cone. Normally held in engagement with the driven cone members by a series of compression springs, the clutch is released by a self-contained annular piston which receives pressure through a hollow driveshaft. Patent 2,575,765 assigned to the Snow-Nabstedt Gear Corp. by Arthur T. Nabstedt and John O. Berndtson.

MAGNETIC "FREEZING" of a 50-50 mixture of soft iron particles and light lubricating oil in a variable-slip nonwearing clutch enables transmitting maximum torque regardless of input speed. Partial magnetization of the clutch results in smooth chatterless and substantially constant torque transmission. In alternative designs, the fluid viscosity is controlled



How a little pull pushes plane production

It's a pulling action that sets Cherry Blind Rivets and makes it possible for them to be installed quickly and easily from one side of the work by one man. They require no bucking—no hammering—no exploding. This is why they are standard in the aircraft industry where they help improve aircraft production in several ways. The use of Cherry Rivets reduces man hours—lowers unit costs—makes possible refinements in design, all of which are important in producing more and better military and civilian aircraft.

Many other industries also find it advantageous to fasten material together permanently with Cherry Blind Rivets. They are used in automobiles, trucks, trailers, busses and railroad cars to rivet double-surface structures, box sections, tubes and ducts in a variety of applications.

Cherry Blind Rivets represent one group in the 10,000 types of fasteners manufactured by Townsend to fabricate wood, glass, plastics, fabrics, and metal products. From this wide selection, Townsend engineers are able to provide you with almost any standard cold-headed fastener or part to help speed assembly—improve your products. They will also help design special fasteners for your particular need. For information on how you can benefit from their broad experience in solving your production problems, write today.

Townsend

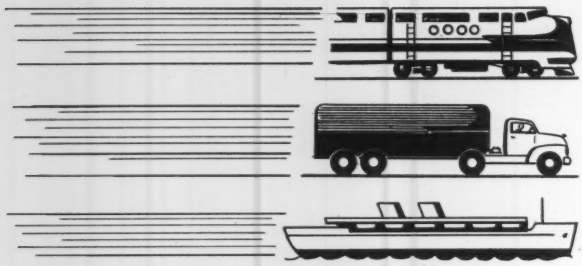
COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Company Division, Los Angeles, Cal.

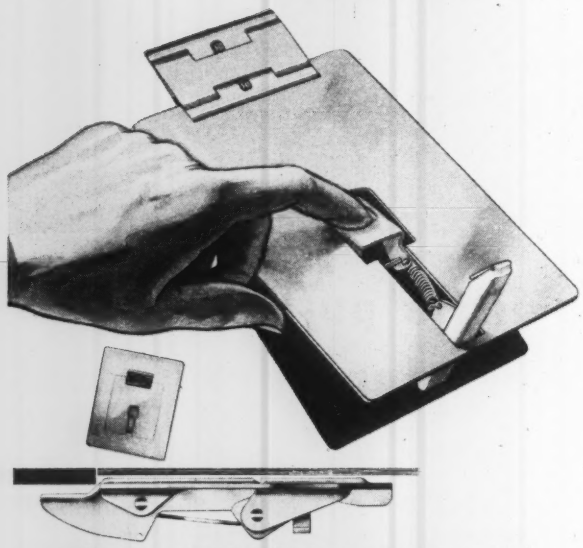
THE FASTENING AUTHORITY—Experience: *over 136 years*—**Capacity:** *sixty-million parts daily*—**Products:** *over ten-thousand types of solid rivets—cold-headed parts—Cherry Blind Rivets—Twinfast Screws—self-tapping screws—tubular rivets—locknuts—special nails—formed wire parts.* **Plants:** *New Brighton, Pennsylvania—Chicago, Illinois—Plymouth, Michigan—Santa Ana, California.*



HARTWELL

Trigger-Action

FLUSH LATCHES AND HINGES



The World's best and most complete line for every application . . .

"Make them *flush, safe* and *simple!*" was the plea of industries to the latch and hinge manufacturers.

So HARTWELL did. *Flushness* for streamlining, efficiency and economy. *Safe,* rugged,compactness for dependable performance. *Simple,* positive-action to speed up maintenance operation.

Finger-tip pressure on the trigger of the latch releases the bolt and permits the door to open. Finger-tip pressure on the bolt, when the door is in place, locks it shut.

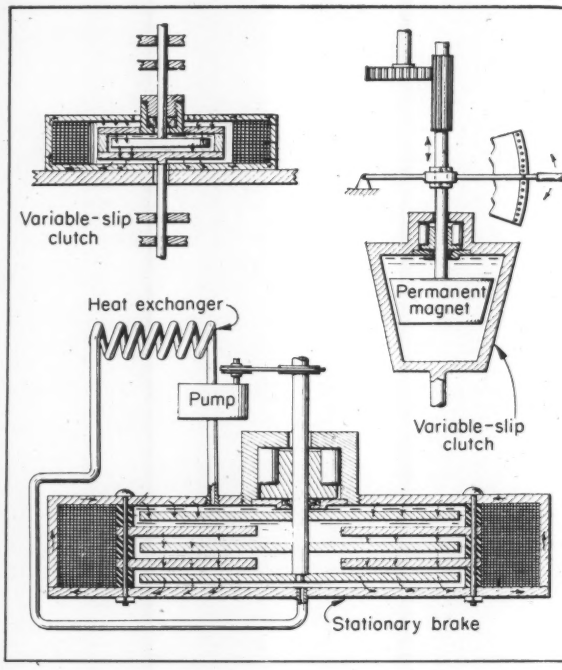
Dynamically *flush* and *safe,* they meet or surpass the most exacting requirements.

Write for engineering specifications and counsel.

HARTWELL COMPANY

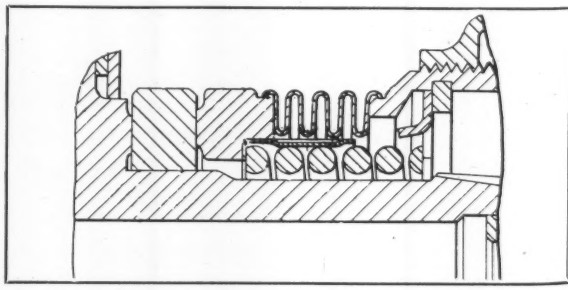
Manufacturers of Flush Latches and Hinges, Fittings and Cable Terminals.
9035 Venice Blvd., Los Angeles 34, Calif.

Noteworthy Patents



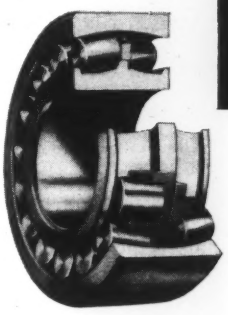
through direct current, alternating current, or built in permanent magnets. By the same principle, brak ing action is achieved simply by making the normally driven clutch member stationary. Heat liberated i the fluid as a result of prolonged slippage may b dissipated by circulating the fluid through a heat ex changer if necessary. Patent 2,575,360 assigned to th United States of America by Jacob Rabinow.

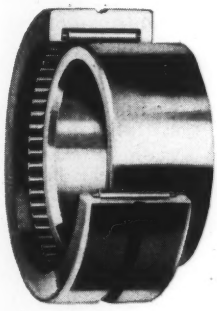
SPLIT DAMPING CUP of half-hard brass damps out vibrations known to produce undesirable squeak howl, and chatter in Sylphon-type bellows shaft seals Positioned endwise by spring pressure through a narrow inside flange, the damping cup wall is ribbed alternately inside and outside to provide contact

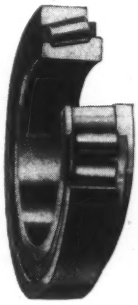


surfaces with the spring coils and bellows corruga- tions. Friction at these areas is claimed to assure quiet seal operation by dissipating vibration energy without detriment to seal effectiveness. Patent 2,574,808 assigned to Chrysler Corp. by R. W. Wolfe.

pulling together...







Working closely with makers and users of all kinds of equipment—from small appliances to giant rolling mills—Torrington engineers have helped solve countless problems involving bearing design, installation and maintenance. They have had many years of experience in the manufacture and application of *all* types of anti-friction bearings.

Have you a friction problem? Would you like to know more about a certain type of bearing in terms of your product? Then call in a Torrington engineer. He will be glad to work with you.

THE TORRINGTON COMPANY

South Bend 21, Ind. Torrington, Conn.

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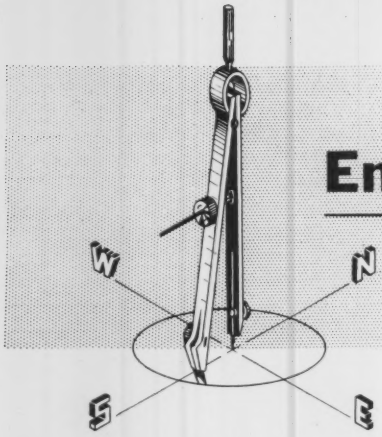
TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Straight Roller • Needle • Ball • Needle Rollers



Engineering News Roundup

Aluminum Cast in Continuous Lengths

Exclusive license for the continuous casting of aluminum and other nonferrous metals by the Goss process has been acquired by Apex Metal Products Corp. of Cleveland. By the new process, molten metal is cast directly into continuous lengths of the cross-sectional form in which it is to be used.

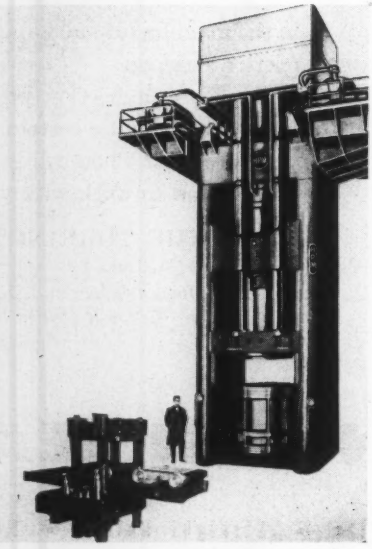
Cast shapes made by the process are expected to be used as screw machine stock, as billets for extrusion, as bar stock for forging, and as slabs for rolling. In the production of bar stock, no intermediate forming is necessary, so that the process represents the shortest possible distance from molten metal to the screw machine or forging hammer. While rod and bar are the easiest forms to produce, hexagons, ovals, wedges, squares and even thin rectangles are possible.

Wide choice in the selection of alloy compositions is claimed to be one advantage of the new process. Inasmuch as no attention need be paid to the extruding, rolling or other forming properties of the alloy, selection of metal can be made primarily for strength, machinability and corrosion resistance. Bars can, for example, be produced of an aluminum alloy that develops high strength without the necessity for heat treatment.

A pilot plant is now in operation, with full-scale production expected in the near future.

Standards Research Started

Systematic studies of standardization and its applications in science, engineering, production and marketing will be conducted through a fellowship announced by Mellon Institute, Pittsburgh. Projects will be organized and supervised by Dr. Dickson Reck, advisory fellow, who will work in co-operation with research specialists of the institute, and national authorities and societies. The fellowship will be sustained by a grant from the Sarah Mellon Scaife Foundation.



Between the small cider press on the left and the towering, deep-draw blankholder press on the right has elapsed 75 years of progress in hydraulic presses. Both are products of the Hydraulic Press Mfg. Co., the cider press being the first model produced in 1877, and the blankholder press the latest 1952 version

MIT Gets New Metals Lab

Dedication exercises were recently held for the new Metals Processing laboratory completed at the Massachusetts Institute of Technology. The building, provided by a gift of $1 million from the Alfred P. Sloan Foundation, will be dedicated to research in all types of metal forming and machine tool work, and toward the understanding of basic phenomena underlying the use of metals in production processes.

About two and one-half floors of the building will be devoted to metalworking, powder metallurgy, foundry and welding equipment. The remaining space of one and one-half floors will contain research laboratories for studies in metal cutting, and lecture halls.

Boron Steels for Aircraft

To determine whether boron steels can be substituted for other types in aircraft production, members of the Alloy Steel Advisory Committee of the NPA have agreed on a project to test several types of the "low-alloy" steel. Final specifications for five special heats of steel have been drawn up. Five alloy steel mills will each produce a test electric-furnace heat, and each heat will be made within the ranges of a "high" and "low" alloying content. A piercing and rolling mill will turn these heats

into bars, tubes and sheet for testing by individual aircraft companies. The SAE Steels Co. will act as the central distributor.

Agreement Reached On Bearing Dimensions

Agreement has been reached on the boundary dimensions of most types of ball and roller bearing units and parts by a ten-nation committee working on this long-range international standardization project. Thirty-five resolutions were passed on the standardization of antifriction bearings at a recent four-day meeting of the International Organization for Standardization (ISO) technical committee No. 4, which met in conjunction with the second general assembly of the Organization.

The committee worked primarily on a proposed general plan drawn up by one of its subcommittees after three years of work. The plan covers ball and roller bearings from a 3-millimeter bore to about 1700 millimeters in outside diameter. Miniature bearings and tapered roller bearings are being separately considered, as well as larger sizes, and will be the subjects of further proposals.

Importance of the decision can be seen in the fact that the international agreement covers more than 1600 bearing sizes. The committee also discussed the problems of tolerances for bore, outer diameter, interchangeability and running accuracy. Recommendations were made on these items on the basis of majority committee opinion. Standardization of rating formulas for calculating sizes of bearings and for definitions of load-carrying capacity were also discussed.

The ISO project, in general, is seeking to standardize terminology and definitions of bearings and bearing parts, nominal dimensions and tolerances of ball and roller bearings, methods of inspection, methods of evaluating load ratings, and dimensions of mounting accessories.

New Betatron Installed

A 22-million volt betatron, mounted on a crane to permit rotation of the radiation beam, will be installed in a new test building at the West Allis works of Allis-Chalmers Mfg. Co. Steam-turbine, centrifugal-pump and hydraulic-turbine parts will be inspected with the new equipment.

Concrete walls 6 feet thick and 20 feet high will shield personnel from radiation. A Harnischfeger bridge crane capable of handling 25 tons will lift specimens. The betatron itself will be capable of rotation through 180 degrees about the horizontal axis and 360 degrees about the vertical axis of the focal spot. Castings will be placed below the unit.

By late spring of 1953, Allis-Chalmers will have built 24 betatrons, ranging from 20 to 24 million volts. With the new betatron to be installed, steel sections from one to about 24 inches thick can be examined.

Switchgear Lab Produces High Power Surges

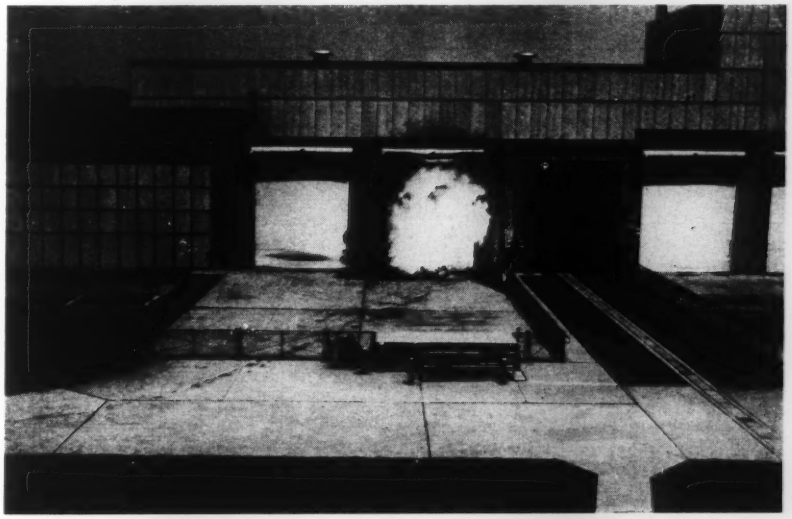
Short circuits of over 5 million kva, the most powerful ever produced in a research facility, can be created for power-equipment tests in the new General Electric switchgear development laboratory recently opened near Philadelphia's International Airport.

Two generators, the largest ever designed for short-circuit testing, combine to provide the necessary power. When operated in parallel, the two units can deliver 5.25 million kva assymetrical or 3.2 million kva symmetrical at 15.5 kv, 3-phase. These huge power surges are used in the development, designing and testing of circuit breakers and other power equipment.

The laboratory, costing over $10 million, consists of a control building, a test building and a high-voltage yard. Five individual test cells, located in full view of engineers in the control center, are ranged along one side of the test building. These are used for tests up to and including 15.5 kv, power being supplied direct from the generators. Short circuit currents as high as 500,000 amperes at 600 volts can be provided, and tests can be conducted at 120 to 1200 volts. In the high-voltage test yard, tests above 15.5 kv and up to 440 kv are conducted.

Two concrete observation dugouts are located in the area between the test cells, high-voltage yard and control building. An underground tunnel links the test and control buildings and also carries the 400 miles of interconnecting electric conductors, as well as steam, water, compressed air and pneumatic film-delivery lines.

An overloaded circuit-breaker "blows" in one of the test cells at G-E's new switchgear development laboratory. Short circuits of over 5 million kva can be created for power-equipment tests



New Reliance Engineering Department Designed for Flexibility and Efficiency

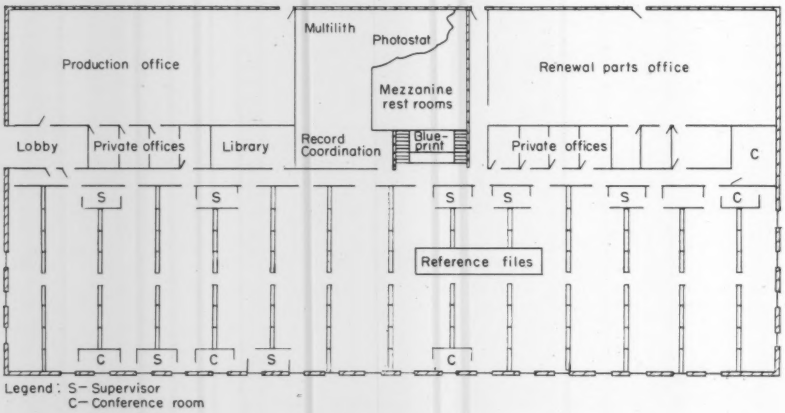
Outstanding among the facilities of the Reliance Electric Company's new $1,800,000 plant in Euclid, O., is the new engineering department which is designed to provide maximum efficiency for the plant's 200 engineers, draftsmen and technicians. In planning its engineering activities and in designing facilities for them, Reliance has devoted considerable attention to installing up-to-date methods of doing engineering work and to devising ways and means of up-grading all such procedures wherever practicable.

Work areas have been designed for personal efficiency, conditioned for comfort and arranged to provide the greatest possible freedom from distraction. Flexibility to permit future rearrangement of facilities has been provided.

A modular plan, based on a 5 by 3 by 1-ft bookcase as the modular unit, was utilized. Making full use of the available area, this plan meets the need for flexibility as future changes may dictate. Bookcase modules are grouped in rows of eight. Alternate shelf openings provide four desks or drafting tables on either side of each row. In this manner 26 interchangeable work areas are provided in the 50 by 200-ft room, shown below. Supervisors are provided with double modules, and conference areas were formed by combining two modules and adding plywood partitions.

Personnel is provided with the privacy associated with individual offices, plus the advantages of one-room visibility, illumination and ventilation. Each draftsman has been supplied with an extra-width shelf to accommodate the largest standard size drawing, ASA "D" size.

Passing lengthwise through the general office area are primary and secondary aisles which minimize congestion and the disturbance accompanying the flow of traffic past individual workplaces. Office services and files are centrally located.



A 12 by 16-ft conference room is located at one end of the building, and there are four smaller semiprivate conference areas, each located close to a particular engineering group.

Illumination is provided by an overhead installation of fluorescent fixtures. A general lighting level of 65 to 85 foot-candles at desk level is maintained, eliminating the need for local lighting on desks and drawing tables.

A combination system which operates under positive pressure to exclude dirt provides ventilation. Seven changes per hour of 100 per cent fresh, filtered air in summer is circulated by means of nemostats which deflect the air at the ceiling inlets.

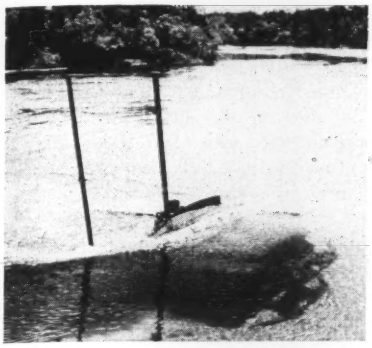
Heat exchangers control air temperature in the inlet fan units. Steam from two gas-fired low presure boilers is used in the heating coils of the exchangers. A continuous convector, using circulated hot water, is mounted along the outside walls to compensate for heat lost through windows and walls.

The use of module sections substantially reduces lateral noise transmission, and its reflection is reduced by a suspended, sound-absorbing ceiling of acoustical tileboard. Thus the general noise level in the engineering offices is well under the limits required for concentration on detailed work.

Extrusion Process Installed

Unpierceable metals can be made into seamless tubing with new equipment recently installed by The Babcock & Wilcox Co. as a part of its multimillion-dollar expansion program. Located in the company's Tubular Products Division works in Beaver Falls, Pa., this equipment produces tubing by the Ugine-Sejournet hot extrusion process developed in France, instead of by conventional piercing and rolling methods. Babcock & Wilcox equipment, the first in this country to use the Ugine-Sejournet process, can, for example, extrude a white-hot billet of selected metal 28 inches long and 8 inches in diameter into a 60-foot tube, 2 inches in diameter in less than 5 seconds' time.

The principal advantage of the extrusion process, however, is not



Picture of a military truck towing a 5000 pound cannon. Snorkel tubes are all that can be seen of this GMC 6 x 6 truck, since the truck is completely enclosed for underwater fording of rivers. The Army driver is equipped with a diving mask for deep going

speed. Metals such as molybdenum and some of its alloys, titanium and certain of the stainless steels, which are difficult or impossible to pierce economically, can be made into useful shapes. A die and a mandrel arrangement form an annular aperture through which the metal is forced to make the tube. By removing the mandrel, which forms the hollow interior, solid bars can be extruded.

Publicize Engineering Work

Few engineers have taken time to tell the U. S. public that engineering genius has been largely responsible for differences in living standards in this country and in other countries, according to H. W. Barclay in speaking before the New York State Society of Professional Engineers.

Vast benefits that the U. S. public has gained from the work of American engineers have gone unrecognized because engineers themselves have not done an adequate job of publicizing their achievements. Mr. Barclay, who is on the staff of the *New York Times,* emphasized the need for a "broader scale of communications for facts about the values, rewards, results and practical public gains produced here by engineers."

Estimating that a total audience of 15 million persons could be reached with engineering information, Mr. Barclay made several specific suggestions as to methods that engineers might use to reach this audience. Among them were: define major projects on which engineering communication is needed; expand the use of available media of communication; organize adequate staffs for communications tasks; and stockpile and index standard data so that the achievements of engineering may be an "open book" and record for the whole world.

Atomic Submarine Gets Keel

The keel has been laid for the *U. S. S. Nautilus,* the world's first submarine designed for atomic power. The keel-laying came 3½ years after the Atomic Energy Commission's first announcement that a contract had been entered into with Westinghouse Electric Corp. "for the construction of an experimental nuclear reactor to meet specifications for eventual use for ship propulsion." Ceremonies attended by President Truman took place at the Groton, Conn., yard of the Electric Boat Div. of General Dynamics Corp.

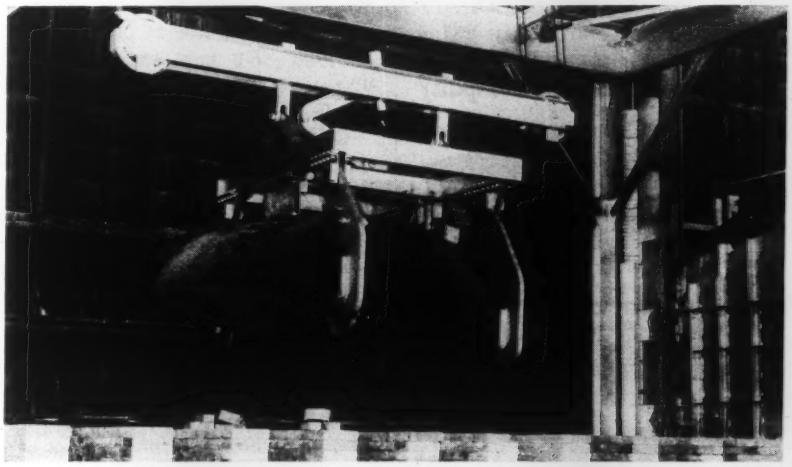
Although the work has been cloaked in silence, Westinghouse engineers report "considerable progress" in the development of the reactor. Research, design and production work is being carried on at Bettis Field, near Pittsburgh, and a land-based prototype is being built at the National Reactor Testing Station near Arco, Idaho. This prototype consists of a nuclear reactor, all its controls, a heat-transfer system using water for extracting energy from the reactor, and the steam propulsion system that converts this energy to power. The propulsion system follows standard marine practice except for measures taken to reduce dimensions and weight.

Powerful Magnet Material Developed

Having the highest recorded coercive force of any permanent magnet material, a new bismuth and manganese material has been developed by the Naval Ordnance Laboratory. With a coercive force of 3000 oersteds, the material exceeds any other permanent magnet except platinum-cobalt alloys in available flux density in short magnets where length to diameter ratio is one or less. Since magnets are made by powder metallurgy techniques, complicated shapes can be processed to close tolerances without machining.

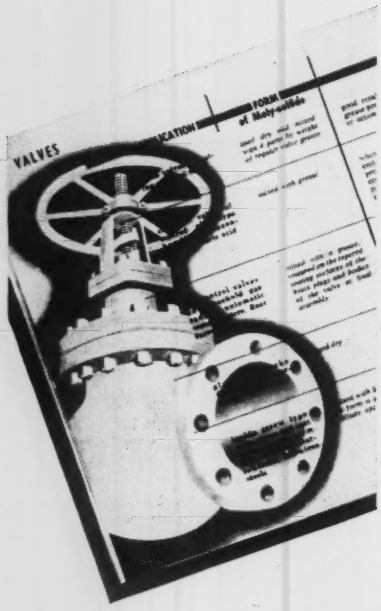
Bismanol, as the new material has been named, is actually manganese bismuthide, prepared as part of a search for magnetic ma-

Red-hot turrets for Army tanks are picked up automatically, quenched in a 50,000-gallon water tank and put on cars for reheating by these huge tongs. Designed by the Heppenstall Co., the tongs handle the 7 to 12-ton turrets by remote control



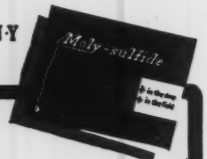
Moly-sulfide
A LITTLE DOES A LOT

is proving effective even where other lubricants have failed



Moly-sulfide, a solid-film lubricant, is proving so useful in difficult friction applications that new uses are found daily. 154 cases of how serious problems were solved are described in our new booklet. Your own problems may be like those described. Write for your copy of this booklet.

Climax Molybdenum Company
500 Fifth Avenue
New York City 36 N Y



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Engineering News

terials not containing critical nickel or cobalt, and which could be compacted in the form of fine particles to form permanent magnets. The particular combination of materials was chosen because of its potentially high magnetic anisotropy — its possession of an axis along which magnetism can be strong, as opposed to one or more axes along which magnetism is difficult to impress.

In the preparation of the magnetic alloy, powdered manganese and bismuth are mixed and heated to 700 C, cooled to 400 C, and aged at that temperature for 16 hours. The alloy is then separated from the mixture by a magnetic separator, and is hot pressed to the desired shape in the presence of a strong magnetic field, which aligns the crystals in the direction of "easy" magnetism.

The magnets thus made not only show a high coercive force, but also have a maximum energy product comparable with Alnico magnets (3×10^6 gauss - oersteds). No technical evaluations of temperature, stability, aging or shock characteristics have been made at the present time.

Roller Chain Improvements

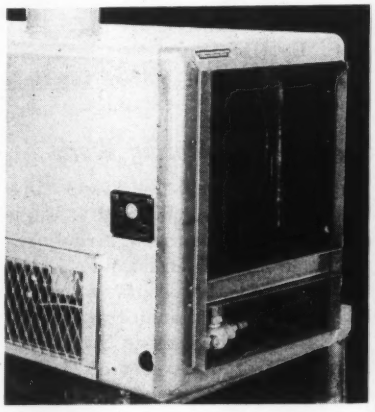
Among the newest improvements in roller chain are two features announced by Morse Chain Co. and Whitney Chain Co. Roller chain incorporating oil-impregnated sintered metal bushings have been announced by Whitney; while Rollpins — compressible slotted steel cylinders—will be used as fasteners by Morse in place of cotter pins. The new features will be used only in certain sizes of roller chain.

Oil - impregnated bushings, requiring little or no lubrication, were developed to operate efficiently where conventional lubrication methods are either not possible or not desirable. Textile mill operations, for example, avoid the use of drives requiring external oiling; and under service conditions of grit or abrasive material, external oiling of the drive results in a materially decreased service life. The new Whitney chains are expected to offer marked advantages in these types of drive.

Rollpins, as available on most of the larger pitches of both standard and heavy series Morse roller chains, are chamfered-end slotted cylindrical pins that compress easily into pin holes smaller than their own diameters, and lock into place until deliberately removed by hammer and punch. According to Morse, the Rollpin is the most durable fastener yet developed for roller chain. Besides providing a greatly extended fastener life, it is equal in shear strength to cold-rolled pins of the same diameter, and will not fail by fatigue even under extremely severe working conditions.

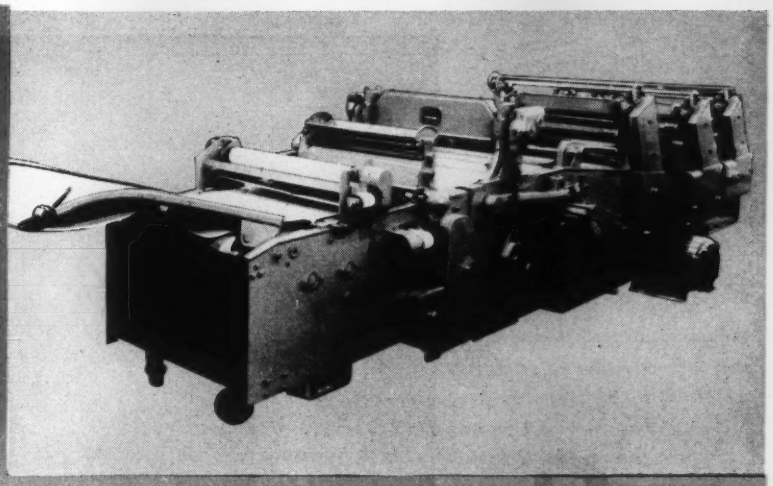
Finish Withstands 875 F

Heat-stable silicone-base finishes are showing increasing promise as finishes for application to hot components of gas heaters and exhaust systems. Air or force-dried, the new formulations withstand high temperatures without powdering



or discoloration, and can be applied by brush, spray or dip to any chemically clean metal surface.

A typical application is to the combustion chamber and outer coverings of gas heaters. Temperatures of 875 F are generated in the combustion chamber of the gas heater shown, a John Zink Co. unit. An aluminum-silicone finish is used to protect the chamber, and outer coverings are protected with colored silicone finishes. According to E. O. Robson, president of the Midland Industrial Finishes Co., temperatures up to 1000 F



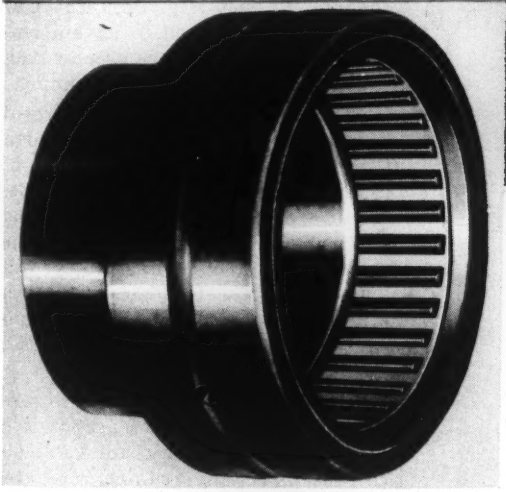
Crank Mechanism of Greer Biscuit and Cracker Cutting Machines

This improved cutting head eccentric operates on the reciprocating principle, at speeds of 50 to 200 strokes per minute. Orange Cage Type Needle Bearings replaced split type bronze bushings, to provide ample capacity within the available space—eliminate former run-in time—assure freedom from roller skewing and bearing trouble.

This Greer Biscuit and Cracker Cutting Machine is an ingenious, high speed machine. It rolls out biscuit or cracker dough to sheet form of desired thickness—cuts out shapes—separates the cut shapes from remaining sheet—and deposits them on the loading end of a band oven. As an example of its capacity, it can produce 1,500 to 6,000 lbs. of 2" soda crackers an hour, according to cutting speed selected. Manufactured by J. W. Greer Co., Cambridge, Mass., makers of continuous production machinery for the baking and confectionery fields.

gains positive protection against roller skewing with

ORANGE *Cage Type* NEEDLE BEARINGS



WRITE for Engineering Data Bulletin on Orange Cage Type Needle Bearings, showing construction, advantages, sizes, capacities, etc. Our engineers, convenient to every industrial center, are glad to discuss any application without obligation.

Orange Cage Type Needle Bearings bring you all the high-load, small-space advantages of conventional needle bearings . . . PLUS the great feature of permanently aligned rollers. This has broadened their use to include successful application on vertical installations—spindles—overhung mountings—and relatively high speed installations. They are less affected by misaligned mountings and uneven loading.

Note that the square end rollers are retained in pockets of a free-floating, land-riding cage of anti-friction, non-ferrous metal. This prevents skewing while running and permits precision-controlled internal clearances for exacting requirements. All rollers and races are "Pentrate" finished to reduce corrosion and friction. Operation is extremely quiet and smooth—service records are exceptionally long and trouble-free.

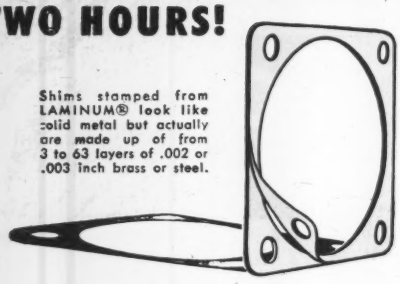
ORANGE

ORANGE ROLLER BEARING CO., Inc. 556 Main St., Orange, N. J.

2 Seconds

CAN SAVE YOU TWO HOURS!

Shims stamped from LAMINUM® look like solid metal but actually are made up of from 3 to 63 layers of .002 or .003 inch brass or steel.



Adjusting bevel gear mesh with a laminated shim is a matter of two seconds to remove a lamination!

The shim in this case is made of LAMINUM®, our exclusive material. It is a "solid" unit built up of 16 layers of .002 brass. It peels quickly and easily. Each shim removed adjusts the bevel gear position by two thousandths.

You save time by easier machining tolerances on the housing; ***you save time*** by eliminating pesky assembly machining; ***you save*** by not tying up a machine intermittently. IT'S EASIER!

SEND FOR LITERATURE

LAMINATED SHIM COMPANY, INC.

SHIM HEADQUARTERS SINCE 1913

Check Our Stampings Division For Your Stamped Parts Requirements

1208 UNION STREET • GLENBROOK, CONNECTICUT

can be withstood easily without blistering or peeling.

Stokes Offers Free Service

Test samples for experimental metallizing will be handled at no cost or obligation in a new service offered by F. J. Stokes Machine Co. Vacuum metallizing (see MACHINE DESIGN, October 1951, Page 141) is a method of depositing a metallic coating comparable to an electroplated coating on any material, conductive or nonconductive. Costs are comparable with other forms of plating. Arrangements for test runs of products or parts for metallizing may be made through the company at 5500 Tabor Rd., Philadelphia 20, Pa.

New Manufacturing Method Developed for Brake Lining

Strands of asbestos web are saturated and completely surrounded with a special frictional binder material in a brake lining manufacturing process recently patented by Russell Mfg. Co. The new material is claimed to have a tensile strength ten times greater than conventional woven brake lining.

In the process, the saturated mass is compressed under high pressure, effecting a density of 1200 pounds per cubic foot. Because of this greater density and tensile strength, according to the company, the new brake lining will not absorb water, has a uniform structure throughout, and has uniform coefficient of friction and rate of wear.

Among other advantages of the new material are quick evaporation of surface moisture, allowing almost immediate braking recovery, and reduction in grabbing and fade.

♦

To be completed within a year, a multimillion-dollar transformer manufacturing plant is being built at Rome, Ga., by the **General Electric Co.**, Schenectady, N. Y. Production at the new plant will begin immediately following its completion, and full capacity is expected to be achieved in 1955.

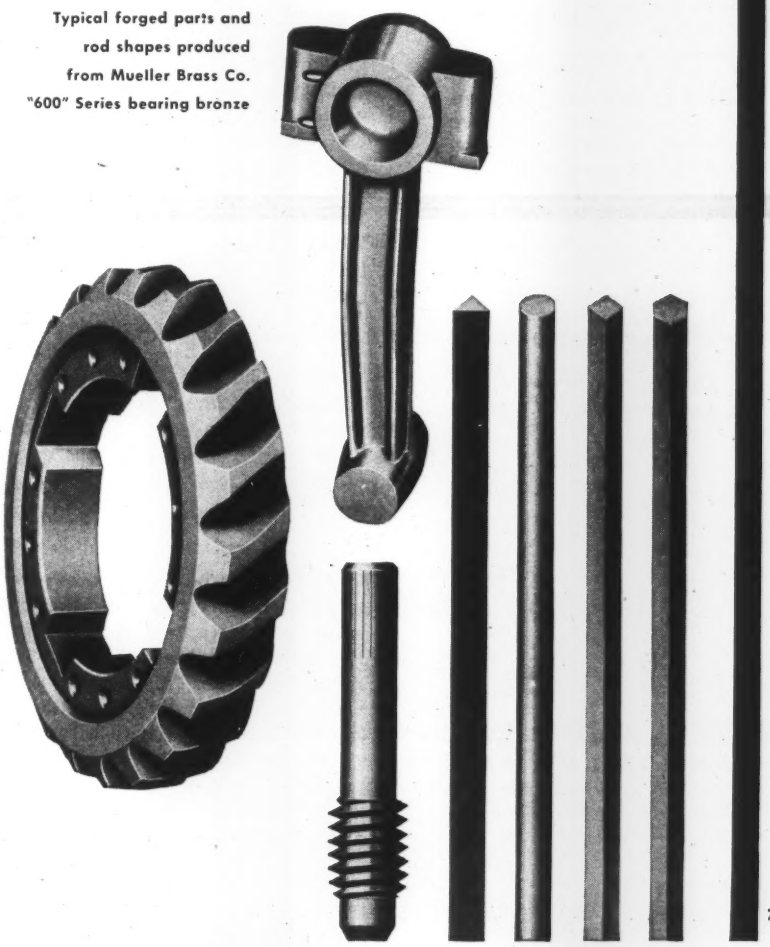
MUELLER BRASS CO.

"600" SERIES

a better bearing bronze containing no-hard-to-get tin

If you use gears, connecting rods or other parts requiring bearing properties, it will pay you to investigate "600" Series, a high strength bronze that *contains no tin*. "600" Series outperforms phosphor bronzes and other bearing metals . . . it will also save time, money, and material. "600" Series bearing metals can be forged into relatively complicated shapes and produce a forging of close-grained homogeneous structure impossible to get in a sand casting. The forged shape is closer to finished size than a casting, often requires less machining, and eliminates the need of a bushing. "600" Series is available in standard and special extruded shapes in 12′ mill lengths. These alloys have a low coefficient of friction, a tensile strength 2½ times greater than cast phosphor bronzes and high resistance to corrosion. There is a "600" Series alloy with the properties to fit your bearing metal need...write today for further facts.

Typical forged parts and rod shapes produced from Mueller Brass Co. "600" Series bearing bronze



MUELLER BRASS CO.

PORT HURON 15,

MICHIGAN

73

For DEPENDABILITY IN TRANSPORTATION

The Correct Fastener for the Job

These Erie bolts have at least one thing in common—they are designed to hold against maximum strains imposed by pressure, temperature, or corrosion. They differ in material, shape and threading as the job directs. For 38 years, we have geared our plant to manufacture these unusual high quality bolts to exacting specifications. No other plant in the world has built more kinds of special bolts than Erie.

This broad experience backed by a high desire to be of service to you is your assurance that Erie is ready to meet your special bolting requirements.

A SUBSIDIARY OF Barium STEEL CORPORATION Strength to the Nation

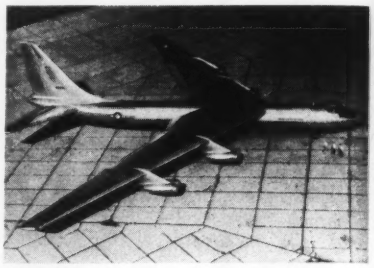
ERIE BOLT and NUT CO.

ERIE • PENNSYLVANIA

STUDS • BOLTS • NUTS
ALLOYS • STAINLESS
CARBON • BRONZE

Representatives in Principal Cities.

Engineering News



Newest photo of the YB-60, Convair's huge eight-jet heavy bomber, shows clearly the plane's swept-wing construction. The experimental plane is longer and taller than the largest plane now used by the U. S. Air Force, with a length of 171 feet and a height of 50 feet to the top of the tail

Fast Coal Unloader Delivers One Carload a Minute

A new conveyor belt installed in Chicago is capable of unloading a full carload of coal in one minute, making the coal unloading installation one of the fastest in the world. The belt, furnished by the U. S. Rubber Co., is 72 inches wide and 942 feet long. It is designed to convey 3000 tons of coal an hour from hoppers at the Rail-To-Water Transfer Corp. to two short belts that feed a universal chute emptying into river boats.

Driven by a 350-horsepower motor, the belt has an operating speed of 560 fpm, and is fed by a five-car unloading facility. It is made of seven plies of 42-ounce duck with a $\frac{1}{4}$-inch rubber cover on top and a 1/16-inch cover on the pulley side.

♦

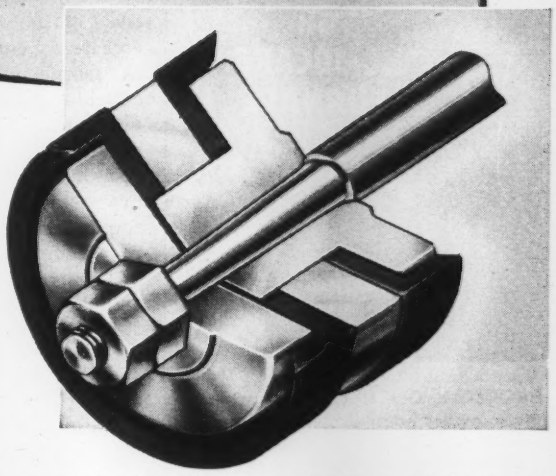
The industrial hydraulics division of **Cessna Aircraft Co.** has been moved to a new, modern plant located at Hutchinson, Kans. The move segregates this division from the company's military and commercial aircraft activities.

♦

Associated with the company for four years, William B. Denniston has been appointed manager of distributor sales for **Shakeproof Inc.**, a division of **Illinois Tool Works**, Chicago.

Save POWER...Save SPACE

Pack hydraulic cylinders with these Johns-Manville Custom-Moulded Packings



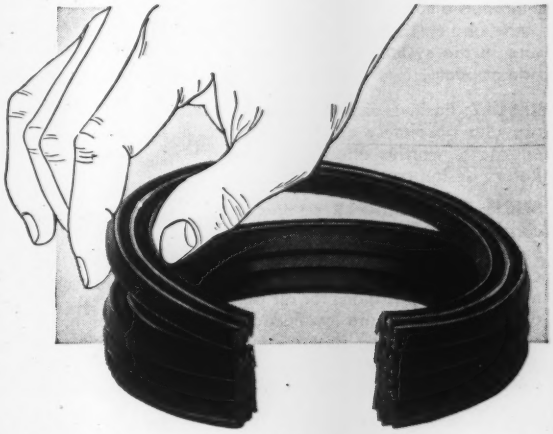
J-M MOULDED CUPS FOR PISTONS—

The power savings that generally result from the use of J-M Moulded Packing Cups are primarily due to the greater sealing efficiency provided by their pressure sensitive lips. The lips form a tight seal under discharge pressure, practically eliminating slippage past the piston. They relax on the non-working stroke, reducing wear and conserving power.

Precision-moulded for accurate fit, these J-M Packing Cups contribute to lower operating costs because of the improved performance of the equipment on which they are installed.

J-M Moulded Packing Cups are supplied in various types for installation on inside-packed pistons. They are furnished in a wide range of compositions of various compounds and fabrics to suit the pressures, temperatures and services encountered.

UNEEPAC FOR RODS AND PLUNGERS—



This new Johns-Manville automatic ring packing was developed to provide maximum sealing efficiency in minimum packing depth. Often used without header or follower rings, Uneepac is designed so that each sealing ring is a complete packing unit. Its pedestal center section protects the lips from damage by gland pressure . . . and positions them so that they are instantly responsive to fluid pressure changes. This construction results in efficient, automatic sealing, conserves power and reduces wear on rod and packing.

Uneepac is easily installed. Each ring seats itself on the preceding ring in the packing gland. Thus, the entire set is aligned concentrically and vertically—nesting perfectly. Uneepac is available for rod diameters from 5/8" up.

For more complete information about J-M Custom Moulded Packings for Hydraulic Cylinders, write Johns-Manville, Box 60, New York 16, N.Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

PROBLEM: Get a compact pump that provides both vacuum and pressure in a gas-air system required for operation of Leeds & Northrup Microcarb Atmosphere Control applied to the Homocarb Furnace equipment.

SOLUTION: One Gast Integral Oil-less Air Pump does double duty. It provides low vacuum to draw a continuous 2 cu. ft. per hr. sample of furnace gas over the atmosphere detector. At the same time the pump maintains a mixture of furnace atmosphere and air at 5 to 10 pounds pressure in the system on the discharge side of pump.

RESULT: Positive displacement pump provides absolutely oil-free air, and eliminates worries about lubrication. Rotary design runs quiet and cool.

SUCH AN EXAMPLE as this may contain a clue to solving a similar or even totally different problem on your desk. You might be surprised at the innumerable applications for air pumps and air motors in the lower capacity ranges. Write today describing your original equipment problem. We'll send full details. "Air may be your Answer."

Gast Application Ideas Booklet — showing 26 design problems solved — sent upon request.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

AIR MOTORS (TO THREE H.P.) · COMPRESSORS (TO 30 LBS.) · VACUUM PUMPS (TO 28 INCHES)

GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.

Engineering News

Foreign Foundry Facilities

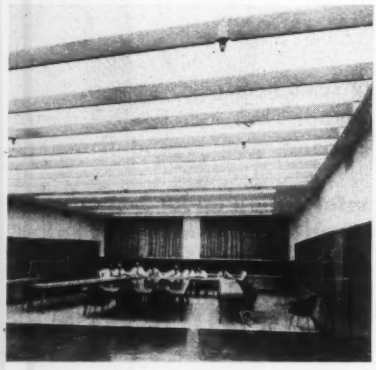
The American mission which recently spent three weeks in Europe checking on heavy casting facilities has reported that there are foundries in France, England, Italy and Germany capable of turning out very heavy steel castings. The mission, composed of representatives of the Air Force, DPA, NPA and heavy casting specialists, were in search of European facilities capable of turning out very large units which can be produced at present by only a relatively few foundries in the U. S., all of which are heavily booked. There they found several companies equipped to produce castings ranging up to 176 tons, and reported that these companies have adequate facilities for machining them.

Versatile Luminous Ceilings

Totally luminous ceilings have shown several distinct advantages in engineering and conference rooms in addition to their normal function of providing even distribution of controlled light. First developed in the 1940's, these all-plastic ceilings were originally evolved to deliver well-diffused, low-brightness light over a large area. But now, according to F. W. Wakefield Brass Co. the plenum spaces above the ceilings are used to distribute air for warmth or cooling, and acoustical controls are being built in.

Air is distributed through corrugations at the end of the plastic sheets, providing a draftless movement of air. Acoustical controls, hung below the ceilings, act along with the panels to provide reverberation control. The ceiling is hung from lighting channels in the true ceiling above it.

Sixty foot-candles of illumination are provided by the completely luminous ceiling in an engineering conference and display room. About 1000 square feet of ceiling is installed



♦

A new company, **Data Engineering Inc.,** has been formed for the designing and manufacturing of data recording instrument equipment. Facilities consist of a fully equipped engineering department, an electronic laboratory and a complete model shop. The company is located at 4608 Ravenswood Ave., Chicago 40, Ill.

♦

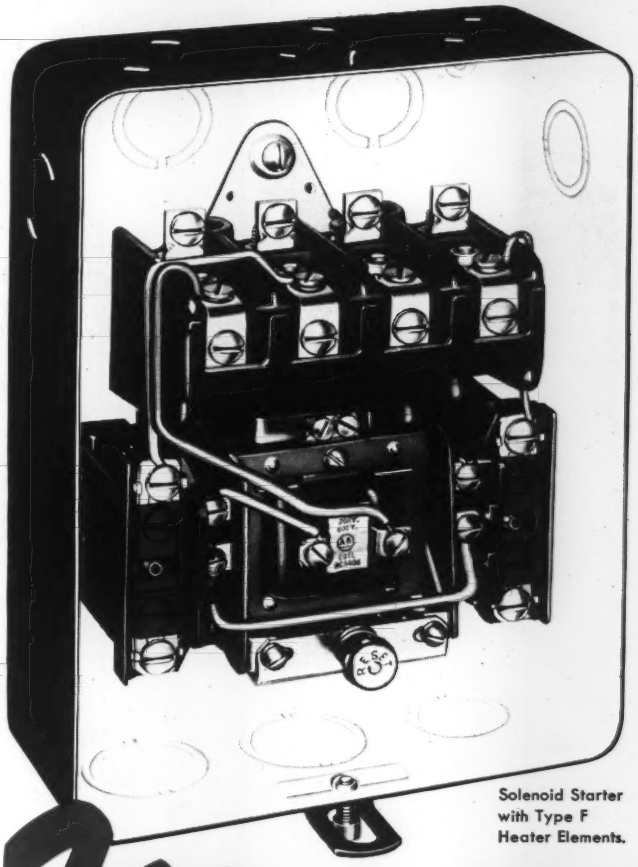
The mechanical division of **Arthur D. Little Inc.,** Cambridge, Mass., industrial research and engineering firm, will be moved to a new and larger building in the West Cambridge industrial area. Ground has been broken for a 30,000 sq ft plant which will include all engineering offices and mechanical facilities of the division. Work performed by the mechanical division includes thermodynamics, heat transfer, machine design, vibration studies, stress analysis and instrumentation.

♦

Apex Smelting Co., Chicago, is constructing a commercial pilot plant in the Pacific Northwest. This plant will produce intermediate aluminum-silicon alloys using clays as a raw material. The alloys, to be produced by the direct reduction process, will be used by the company in its products and also will be available to other metal users.

♦

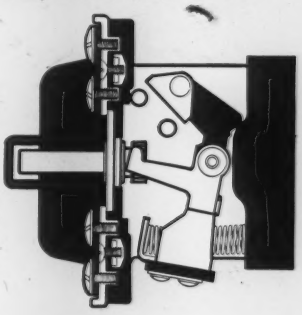
Hagan Corp., Pittsburgh, has been awarded a contract by the United States Air Force to design and construct an automatic control system for the high altitude engine test facility at the new Arnold Engineering and Development center at Tullahoma, Tenn. This test facility will make possible the testing of turbo jet and ram jet power plants under simulated flight conditions and extremely high altitudes.



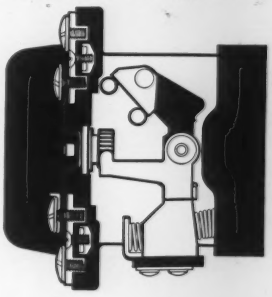
Solenoid Starter with Type F Heater Elements.

THERMAL OVERLOAD RELAY WITH CONVENTIONAL DUAL UNIT

Ordinarily, A-B overload relays have a soldered ratchet spindle (yellow) that is separated from heaterstrip (red). Heat radiated by overload heater melts solder on spindle and releases ratchet.



THERMAL OVERLOAD RELAY WITH SUPER-FAST COMBINATION UNIT

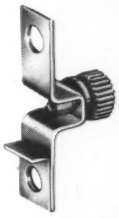


New, super-fast element has soldered ratchet (yellow) brazed directly on heater strip (red), permitting quick transfer of heat to melt the solder and thereby release the ratchet.

new SUPER-FAST COMBINATION UNIT

for protecting hermetically sealed motors used in refrigeration compressor service

Combination Unit
for super-fast operation



TYPE F ELEMENT
Soldered ratchet spindle is brazed to heater for rapid conduction of heat to solder.

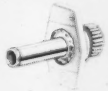
ALLEN-BRADLEY CO.
1316 S. Second St.
Milwaukee 4, Wis.

Most motors used for hermetically sealed compressors are cooled by the refrigerant circulated over the motor windings. They are worked beyond the limit of air-cooled motors, and have little overload reserve.

To give dependable overload protection to these hard-working motors, Allen-Bradley has added the new Type F quick-acting heater element. Its special construction, described above, makes it respond within a few seconds to any overload, and trips the overload relay before motor burnout occurs.

If you need motor controls that are quick-acting in case of overload, specify Type F combination elements for Allen-Bradley solenoid starters.

Dual Unit
for average operation



SPINDLE

HEATER

ALLEN-BRADLEY
OVERLOAD PROTECTION

A-B Quality

5-52-MR

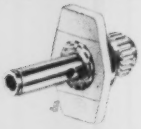
Pick the right spindle to fit the starting cycle.

Insert the spindle in the A-B thermal overload relay.

The relay is ready for the heater element.

It's so easy to provide Starting and Running Protection with Allen-Bradley Thermal Overload Relays

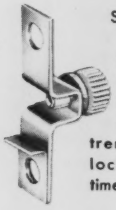
INTERCHANGEABLE RELAY SPINDLES



TAN SPINDLE—for normal allowable locked rotor time and long starting time.

RED SPINDLE—for normal allowable locked rotor time and normal starting time.

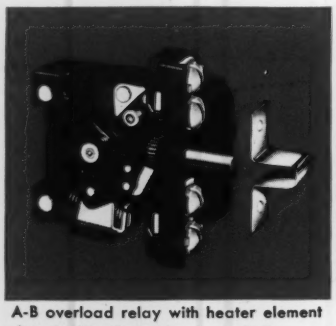
GREEN OR GRAY SPINDLE—for low locked rotor current and short allowable locked rotor time.



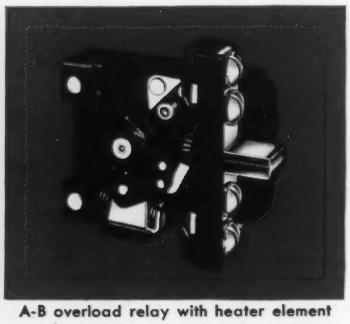
SUPER-FAST SPINDLE—for low locked rotor current and extremely short locked rotor time.

FIRST—to provide locked rotor protection—pick the overload relay spindle (see pictures at left) that matches the motor characteristics. There is an Allen-Bradley relay spindle to meet every need.

SECOND—to provide running protection—pick the heater element (see pictures at right) to fit motor full-load current. There is an Allen-Bradley heater element for every rating. This two-way protection is standard for all Allen-Bradley solenoid motor controls.



A-B overload relay with heater element detached to show the relay spindle.



A-B overload relay with heater element mounted in place over the relay spindle.

INTERCHANGEABLE HEATER UNITS

LOW RATING

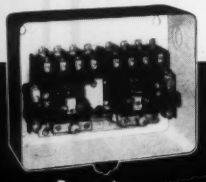
MEDIUM RATING

HIGH RATING

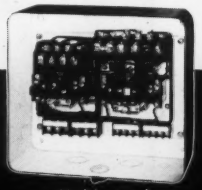
ALL ALLEN-BRADLEY SOLENOID MOTOR CONTROLS HAVE TWO-WAY OVERLOAD PROTECTION

Manual Starter

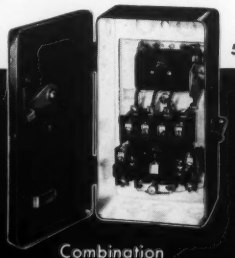
Automatic Starter



Reversing Starter



Multispeed Starter



Combination Starter

5-52-MR

A-B Quality

ALLEN-BRADLEY

QUALITY

ALLEN-BRADLEY CO.
1316 S. Second Street
Milwaukee 4, Wis.

New Alkyd Plastics Are Improved for Insulation

Insulation resistance that compares favorably with phenolic and melamine plastics is now provided by new commercially available thermoset alkyd plastics, reports Dr. M. H. Bigelow, technical director for the Plaskon division of Libbey-Owens-Ford Glass Co.

This increase has been accomplished by controlling the effect humidity has upon insulation resistance through careful attention to several factors. Among the most important of these were selection of the best base resin, use of the proper filler and silicone treatment of that filler, and increased monomer concentration. Each of these factors has a primary effect upon resistance to humidity.

The new alkyd molding materials, of which Plaskon manufactures five types, have been used successfully in plugs and receptacles, capacitors, condensers, connectors, terminal blocks, and other automotive and aviation equipment.

♦

Consolidated Industries Inc., West Cheshire, Conn., is expanding its plant capacity to provide added facilities for titanium forging operations. Several new and larger drop hammers have been installed to provide a complete range of forging sizes.

♦

A. W. Payne has retired as chairman of the board of **Crane Packing Co.,** Chicago, and has been succeeded by his older brother, Frank E. Payne, who founded the company. Karl V. Rohlen, former vice president and general manager, replaces Frank E. Payne as president.

♦

Formerly sales engineer in New York and adjoining areas, Robert T. Jones has been appointed field engineer by the **Chiksan Co.,** with headquarters at the company's main plant in Brea, Calif. Mr. Jones will specialize in hydraulic application of ball bearing swivel joints, particularly in the aircraft field.

The S.S.White flexible shaft couples the trip odometer mechanism to the reset knob. The shaft makes it possible to place both the instrument and the knob wherever desirable both for appearance and for convenience. This extra freedom that S.S.White flexible shafts give in locating coupled parts is a mighty important advantage in designing any equipment.

The shafts will prove useful in many other ways. Their installation presents no problems—they can by-pass obstacles in their path—will operate around turns — are simple to connect — and require no alignment. Furthermore, they are designed to provide smooth, positive operation at all times.

There's no simpler way to transmit power or control in paths other than straight lines. It may pay you to check your present methods of coupling and see if you can't possibly do it better, faster, easier and more economically with S.S.White flexible shafts.

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WRITE FOR CATALOG

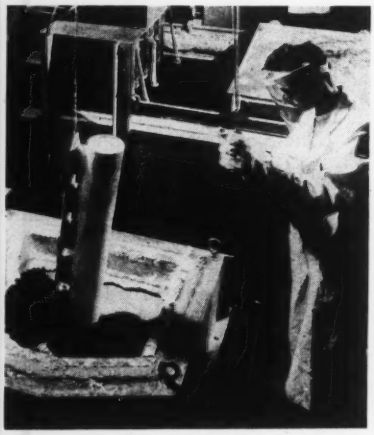
Engineering News

New Aluminum Hot-Dip Process

Described as simple, practical and inexpensive, a new hot dipping process for producing an aluminum base alloy coating over ferrous metal has been developed by General Motors Research Laboratories. Two uses are foreseen for the coating: as a corrosion or rust-resistant coating; or as a heat-resistant coating when diffused by heat treatment.

Although other hot-dipping methods are used for coating steel with aluminum, they appear impractical commercially, according to A. L. Boegehold, assistant general manager of the Laboratories. Pilot plant production has already demonstrated the feasibility of the new "Aldip" process. Continuous coating is also possible.

Properties of the aluminum-coated steel vary with steel composition, dipping time and temperature, and subsequent heating of the coated material. As yet, properties have not been fully evaluated. Microscopic examination shows, however, an outer coat of aluminum with some iron. The second layer, next to the steel, is an iron-aluminum alloy.



One big problem in the six-year development of the new technique was the design of a container durable enough to handle the hot salt flux used for preheating, and the dipping bath. No method had been found to withstand the 1280 to 1400 F temperatures involved. The final solution was to line an outside steel shell with porous supporting bricks. Salt permeated the bricks when the furnace was filled, providing a lining of the same active salts used in the process.

♦

The organization of a group devoted exclusively to applied mathematics has been announced. **Mathematical Computing Services,** 105 Court St., Brooklyn 2, N. Y., will specialize in performing services for industries and universities desiring engineering calculations of a high degree of complexity and the treatment of related mathematical problems in the field of mechanical engineering. The company's staff consists of consultants who hold doctorate degrees and who are qualified to treat problems in applied mathematics related to the physical sciences.

♦

A $100,000 expansion of its rubber roll covering facilities has been completed by **Quaker Rubber Corp.,** division of **H. K. Porter Co. Inc.,** Philadelphia. Included in the new department are lathes, grinders, overhead traveling cranes, testing and laboratory facilities. The company also recently put into operation a new compounding and mixing building in Philadelphia.

Report on Materials

Loss of steel due to the steel strike has already had a severe effect upon the delicate balance of supply and demand of this material. As of press date, about 13 million tons of steel had been lost during the work stoppages in late April, early May, June and July. Thus, well over 10 per cent of the minimum production of 113 million tons expected during 1952 will not be available.

In effect, this loss of steel production sets the whole supply situation back almost a year. Working at maximum rate, steel producers could not approach the 105 million ton figure registered during 1951. Immediate effects are that normal fourth-quarter orders will probably

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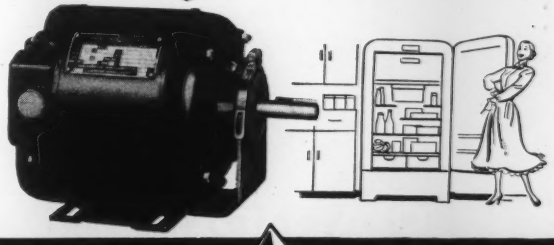

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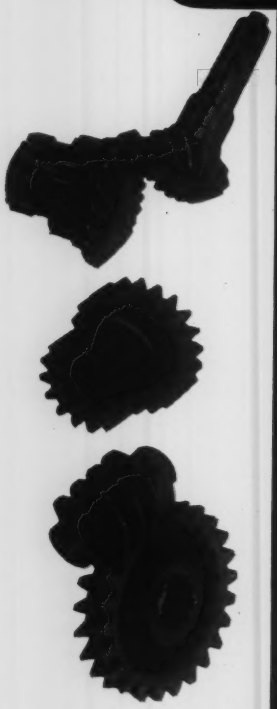

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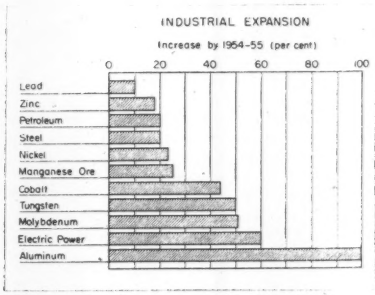
For FINE GEARS

not be accepted, since steel companies already have on their books unfilled third-quarter (and some second-quarter) orders.

Long-range effects are that decontrol will probably be slowed down to a crawl. H. H. Fowler of NPA, in an early statement, has already forecast that first decontrol actions would be delayed from late 1952 or early 1953 to the middle of 1953. This estimate seems quite optimistic considering the tonnage lost, and "free" steel will probably not be available until very late next year or even 1954.

Other Metals: The long-range situation in other metals is considerably happier. Production capacity is increasing at an all-time record rate and, barring unforseen breakdowns in the bandwagon of production and expansion as has occurred in steel, will provide quite a bit of relief within the next year.

About 52 per cent of the new facilities planned to be built between 1950 and 1955 are already in place. By the end of 1953, the expansion program is expected to be 94 per cent complete. In more detail, expansion figures for various metals are:



STEEL: Increase from 100 million tons in 1950 to 120 million tons in 1954.

ALUMINUM: Primary output will be doubled between 1950 and 1955, with a production of 719,000 tons in 1950, 1.1 million tons in 1952 and 1.5 million tons in 1955.

ZINC: 1.3 million tons, domestic and imported, by 1955, 242,000 tons or 18 per cent increase over 1950.

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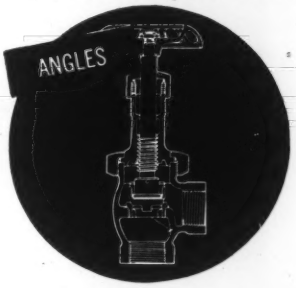

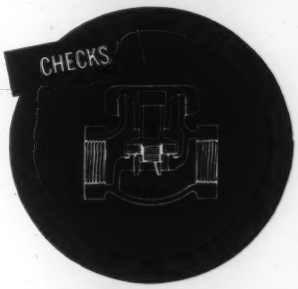

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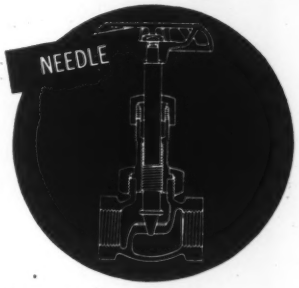

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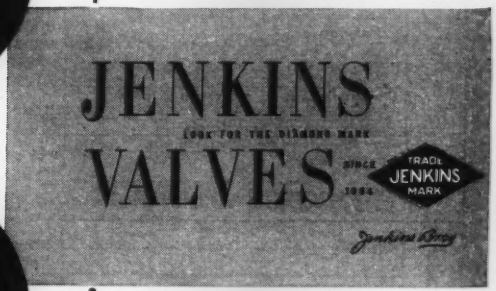

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AMBLER ACP PENNA.

Technical Service Data Sheet

Subject: INDEX OF ACP CHEMICALS FOR METAL PRESERVATION AND PAINT PROTECTION

METAL	OPERATION	ACP CHEMICAL
ALUMINUM	*Cleaning*	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
BRASS	*Brightening*	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK"
	Corrosion Prevention	"CUPROTEK"
	Soldering Flux	"FLOSOL"
COPPER, BERYLLIUM, AND COPPER ALLOYS	*Brightening*	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK"
	Coating Steel with Copper	"CUPRODINE"
	Corrosion Prevention	"CUPROTEK"
	Scale Modification	"RIDOXINE"
	Soldering Flux	"FLOSOL"
	Stripping Copper Coatings	"ACP COPPER STRIPPING SOLUTION"
GALVANIZED IRON, ZINC, AND CADMIUM	*Cleaning*	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
IRON AND STEEL	*Chromate Coating, in Preparation for Painting*	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
	Rust Proofing	"PERMADINE" "THERMOIL-GRANODINE"
	Rust Removal—Brush, Dip, or Spray	"DEOXIDINE"
	Soldering Flux	"FLOSOL"
MAGNESIUM	*Cleaning*	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Pickling	"RODINE (M-200)"
STAINLESS STEEL	*Cleaning*	"DEOXIDINE"
	Coating with Copper	"CUPRODINE"
	Pickle Polishing	"RODINE"
	Soldering Flux	"FLOSOL"

CHEMICALS ACP PROCESSES

WRITE FOR DESCRIPTIVE FOLDERS ON THE ABOVE CHEMICALS AND FOR INFORMATION ON YOUR OWN METAL PROTECTION PROBLEMS

CHEMICALS ACP PROCESSES

Engineering News

NICKEL: 132,000 short tons, do mestic and imported by 195 30,700 a year over 1950.

COBALT: 18 million pounds, do mestic and imported, in 1954, 8 mi lion over the 1950 supply.

LEAD: 1.3 million short tons i 1955, domestic and imported, 135 000 tons over the 1949 supply.

MANGANESE: 25 per cent increas from 1950 to a total of 2.5 millio long tons in 1954.

MOLYBDENUM: 58 million pound in 1955, 51 per cent over 195 figure.

TUNGSTEN: 26 million pounds i 1954, a 50 per cent increase ove 1950.

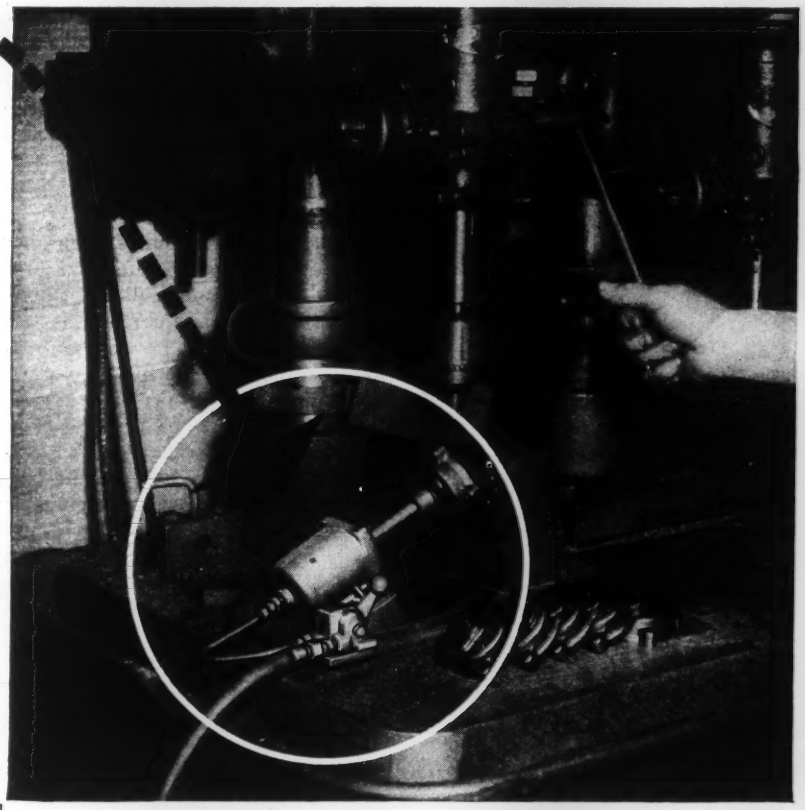
In several of these metals, th figures should be taken with grain of salt since certain limita tions exist, caused by dependenc on foreign imports or difficulties i increasing production of domesti ores. Nickel, cobalt and coppe fall into this category.

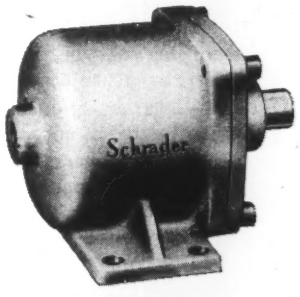
Plastics Expansion: Productio of plastics materials will be mor than double the 1950 level by 1955 Additions to plant capacity wil make possible a production figur of 4.6 billion pounds at that time as against 2.1 billion pounds i 1950. The main increase will b felt in twelve materials: phenolic vinyl, styrene, urea and melamine alkyd, cumarone-indene, polyester acrylate, silicone resins, cellulos plastics, plastic type nylon, an polyethylene. A $441 million capi tal investment will be made to in crease plant facilities.

More Aluminum and Copper: B product manufacturers may obtai larger supplies of aluminum an copper through self-certification in accordance with a new amend ment to Direction 1 of CMP Regu lation 1. Smaller manufacturers wil receive a substantial increas by the new amendment.

NPA emphasizes, in noting the increased amounts, that class B product manufacturers must obtai all controlled materials by self authorization or by filing a form CMP-4B, not both. On the other hand, any manufacturer who has

Simplify any work-holding problem





ClampAir Cylinder

Watch a worker making ready for a simple drilling operation. He places the work in a fixture and hand-clamps it. With everything all set to go, you'll find he takes as much as ten seconds just to grip the work tightly in the clamp.

Multiply that by thousands of machining operations in a normal high production shop. You'll find a substantial portion of work time is used up before actual production is begun.

You can eliminate nearly all of this lost time with the new Schrader ClampAir. What's more, since the ClampAir takes no more effort than opening a valve, high-priced workers are not tired by useless labor.

The ClampAir is actually a bantam air cylinder, with plenty of power to hold work firmly in place—with the same holding force every time. That means the end of rejects caused by inconsistent holding forces.

The number of places where ClampAir can serve you well is on drill presses, milling machines, gluing operations, and others too numerous to mention. In all of these, production rates can be upped to higher percentage brackets with ClampAir. And, since ClampAir is basically a push type cylinder, it can be used in many other spots where you need a short, hard stroke.

It's easy to find out how ClampAir can shorten production time, increase worker efficiency. Write, outlining the applications in which you are interested—or fill out the coupon below. We will be glad to help you determine your needs.

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Engineering News

received allotments in the third quarter for amounts less than allowed by self-certification may increase to the new limit for the third quarter without reapplying to NPA. The new limits are:

COPPER: 10,000 pounds if previously entitled to self-authorize orders within a product class for 500 pounds or less per quarter; 20,000 pounds if previously entitled to 3,000; 40,000 pounds if such usage does not exceed 75 per cent of the base period.

ALUMINUM: 20,000 pounds if previously entitled to 1000 pounds or less; 40,000 pounds if previously entitled to 4000; 60,000 pounds if usage does not exceed 75 per cent.

In addition to these increased allotments allowed by NPA, third-quarter allotments for producers of some consumer items have been raised from 35 per cent to 50 per cent of base period usage.

Conservation: Much emphasis has been placed on "conservation" to help save critical materials. In many places, "conservation programs" have concerned themselves mainly with the collection and reclamation of scrap. But conservation has much broader implications. Basically, conservation starts at the drawing board and requires the use of the most efficient design, manufacturing and materials handling. Considered in this light, conservation of materials should not only be a temporary measure taken in time of relative materials shortages, but can also be a valuable permanent addition to the program of any company that wishes to reduce materials and processsing costs to the minimum.

In this connection a booklet, *Industrial Conservation*, presents a very neat and concise summary of possible organizational setups for conservation. Prepared by the Conservation Div. of the Defense Production Administration, the booklet outlines the method for proposed in-plant conservation about as follows:

A well-coordinated activity with responsibility for all phases centered under one head, is the most likely to produce satisfactory results. The central conservation group may be either a specialized department, a committee of department heads, or both.

CONSERVATION DEPT: The head of the department should report either to the general manager, or in the case of companies having several plants, to one of the local major executives. Where the operation is large enough to justify it, conservation departments are broken down into divisions, with a supervisory group co-ordinating all conservation activities. There can be divisions dealing with materials, improved manufacturing methods and processes, reclamation and salvage, and information and education.

CONSERVATION COMMITTEE: In a large manufacturing operation, it is desirable to have both a conservation department and a conservation committee. A conservation committee should normally include the chiefs of engineering, manufacturing, inspection, accounting, purchasing, and research. The foremen and workmen should be represented. The responsibilities of a committee are similar to those of a board of directors—to discuss and evaluate all proposed conservation projects, and to support the department in carrying out the work on approved projects.

DETAILED DUTIES: In one type of organization, with a conservation committee and a conservation department, the department is divided into four major sections, each under a supervisor. The work of each section is briefly as follows:

Materials Section: The responsibilities of the Materials Section include materials substitution, materials handling and storage, materials utilization, and materials disposition. The materials section includes personnel qualified to suggest materials substitution from a manufacturing rather than a strictly engineering standpoint—that is, where substitution may bring about a lower cost without impairing the performance of the finished product, or may make possible the use of idle or inactive stock.

Handling and storage are studied to see that proper steps are taken to avoid deterioration and damage. This study of materials utilization includes (1) checking

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"Designing for Shock Resistance" sets forth the principles used by the Navy Department in design of shock-proof equipment for shipboard applications. *Published in "Machine Design" Dec. 1950 — Jan. 1951.*

"Shock Testing of Airborne Electronic Equipment" describes the characteristics of shock and tells how shock testing machines are used. *A paper presented at the Dayton Airborne Electronics Conference, 1951; later reprinted in "Tele-Tech".*

"How to Evaluate Shock Tests" tells how mechanical structures respond to shock and shows how such response can be evaluated under controlled test conditions. *Originally published in "Machine Design" December 1951.*

These Barry reports are part of the complete service we offer in handling shock and vibration problems. When you have an isolation problem, call the nearest Barry representative, or ask our field engineering service to help you.

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to see that the greatest possible number of parts are made from a given piece of stock and (2) arranging for the use of random leftover sizes which might otherwise be regarded as good for nothing but scrap. In many companies, the materials section handles the final disposition of obsolete and surplus stock.

Manufacturing Processes Section: An increasing number of companies are stressing conservation at the designer's drawing board, to minimize changes after production gets under way. In one case, preliminary drawings are submitted to a committee made up of specialists in engineering, production, tooling, methods and materials. This committee determines (1) the most economical and efficient way to make the part, (2) whether simplification of design could speed production, (3) whether a different process would make an equally good part at a lower cost, (4) whether the material specified is available and best for the job.

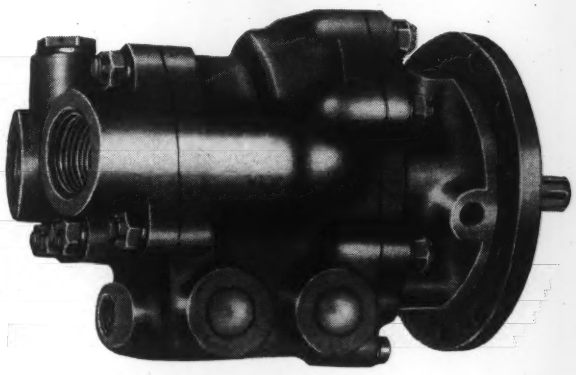
Improved manufacturing processes include better methods of performing the same operations, as well as complete changes in process to produce an equivalent part.

Standardization and simplification can be of the greatest importance in this field—for example, eliminating a high finish where it is not needed, redesigning a part to eliminate an operation, making one component interchangeable in several assemblies, and eliminating uneconomical runs.

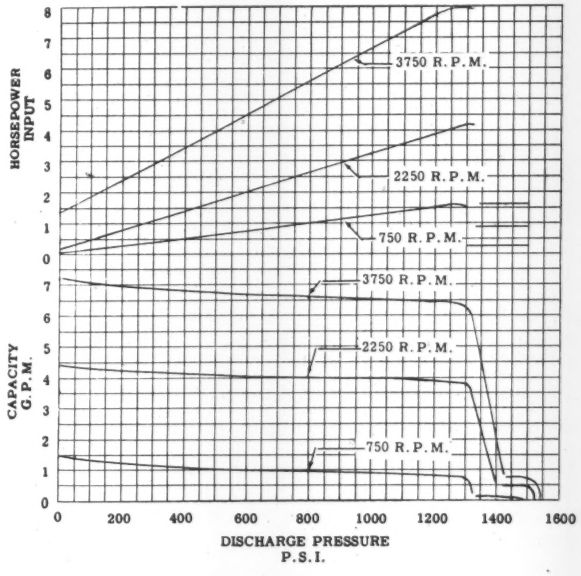
Reclamation Section: Reclamation and salvage are usually handled together in a separate section of a plant's conservation department. Scrap analysis and reject analysis are two of the most important activities of this section.

Information and Education Section: By information is meant the distribution to various plants and departments of full information on specific methods, improvements and conservation projects. By education is meant a general planned program to make employees "conservation conscious." All too often an improvement which helps the cause of conservation may be ap-

SIX BIG REASONS for using Pesco unloading hydraulic gear pumps:



Capacity: 2 g. p. m. @ 1500 r. p. m. @ 1250 p. s. i. Maximum operating pressure 1500 p. s. i. Weight: 8.9 lbs. approx.



This chart shows performance characteristics of Pesco Unloading Pump. Write for detailed engineering drawings and performance data.

1. Fewer parts

2. Easier to recondition

3. Longer service between overhaul periods

4. Lighter weight

5. Lower initial cost

6. Lower maintenance costs

The Pesco *Unloading* Hydraulic Gear Pump is the most economical and dependable pump built for applications where a variable volume of hydraulic fluid is required. This Pesco pump automatically adjusts flow of fluid to increasing and decreasing demands of the hydraulic system. It incorporates a main and a pilot pump as well as unloading and relief valves in one unit. And it's "pressure loaded"—Pesco's exclusive, patented design principle that assures extremely high operating efficiencies over a long, trouble-free pump life because it *automatically* compensates for wear. For the complete story write today.

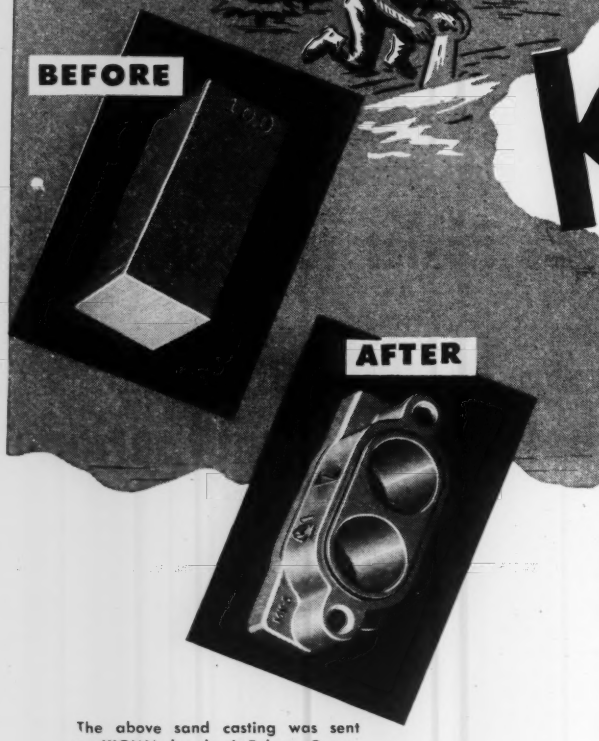
engineering Pesco production

PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD BEDFORD, OHIO

TODAY ALL Metals Are Precious!



PRECISION FROM **KIOWA** PRINT TO PRODUCT

Helps You CONSERVE Costly Materials . . . .

The above sand casting was sent to KIOWA by the LeFebure Corporation of Cedar Rapids, Iowa. Through die casting, the part was redesigned, and then completely machined ready for assembly, as shown above. The redesign has accounted for a tremendous saving of both labor and material.

- Zinc Base Die Castings
- Brass, Bronze, Aluminum Sand Castings
- Aluminum Gravity Die Castings

In days gone by we've always thought of the precious metals in terms of gold and silver . . . but not anymore!

With *material shortages* a byword in today's industrial production, just about every metal can be considered "precious." That's why it's so important to utilize what you can obtain to the fullest extent.

Economy-minded firms throughout the Midwest have called in KIOWA'S famous redesigning service in order to save costly materials and unnecessary labor.

Why not give KIOWA an opportunity to stretch your "precious metals" . . today?

KIOWA CORPORATION 25TH ANNIVERSARY

KIOWA CORPORATION

plied only at the spot where it originated, due to lack of mechanism to distribute information about it through the company. By means of engineering bulletins, meetings and training courses, new developments are brought to the attention of those who should be familiar with them. The trained employee who is "conservation conscious" is an asset to any organization. This conservation consciousness throughout a plant is attained by a sustained, co-ordinated program.

Copies of *Industrial Conservation* may be obtained by writing Conservation Div., Defense Production Administration, Washington 25, D. C.

Scarce Materials: A number of items have been removed from NPA's Designation 1, the list of scarce materials which are subject to "hoarding controls." The action was taken to bring the list up to date by reflecting changes in the supply-demand situation of materials since November, 1951, date of the last amending order. In the revised list, items starred (*) have been added or are changes.

Chemicals

Alkyl phenol
*Alkyl phenol resins
*Alkyl polysulfide polymers (Thiokol polymers, trade name)
*Butadiene
*Butyl phenol
*Melamine resins and molding powders
*Monochlorotrifluorethylene
Polyethylene
Polyethylene resins
Polytetrafluorethylene
*Polyvinylidene chloride and copolymer resins
*Selenium compounds

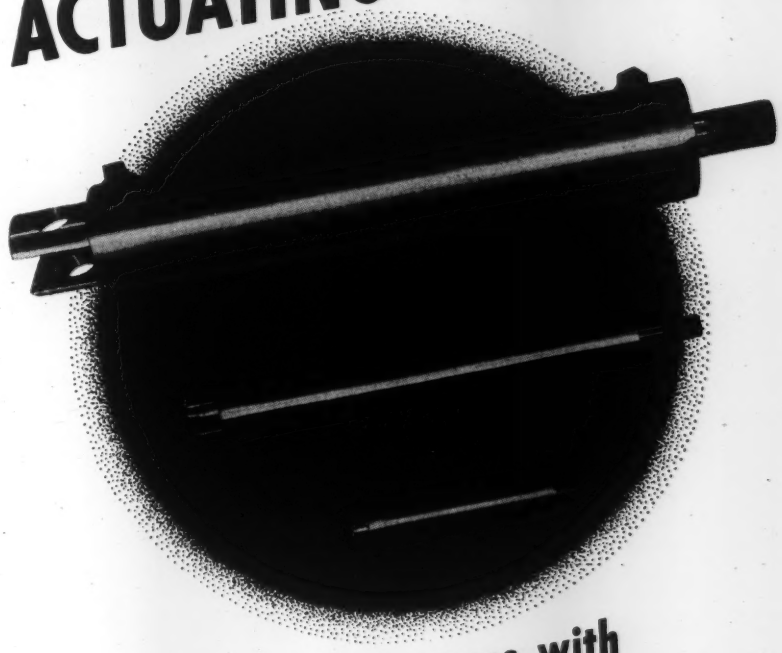
Iron and Steel

Iron:
Pig iron
*Gray iron castings (including soil and pressure pipe and fittings) rough and semifinished; malleable iron castings, rough and semifinished
Steel (carbon, including low alloy, high strength alloy, and stainless): Ingots and semifinished steel, including skelp; steel castings, rough and semifinished; structural shapes and piling; plates; rails and track accessories; wheels and axles; bars, hot-rolled, including light shapes and reinforcing; cold-finished bars; pipe; tubing; wire, wire rods and drawn wire products; tin plate, terneplate, and tin mill black plate; hot-rolled sheet and strip; cold-rolled sheet and strip; other mill shapes and forms
Forgings, rough
*Non-nickel-bearing stainless (i.e., containing less than 1 per cent nickel)
Iron and steel scrap

Metals and Minerals

Aluminum:
Primary and secondary in crude form
Semifabricated shapes, castings (including die); forgings, plate, sheet, and strip; foil; rolled structural shapes, rod, bar, and wire; extruded shapes, tube blooms, and tubing; powder, flake, and paste
All aluminum and aluminum-base scrap containing commercially recoverable aluminum

Electrol
ACTUATING CYLINDERS



Built for Air or Oil Systems with Operating Pressures Up to 3,000 P. S. I.

To insure long, trouble-free service life . . . Electrol Actuating Cylinders are built with Chromium plated piston rods — and precision-honed seamless steel cylinders. Also, by Cadmium plating steel parts, and anodizing aluminum components, there is no chance for corrosion.

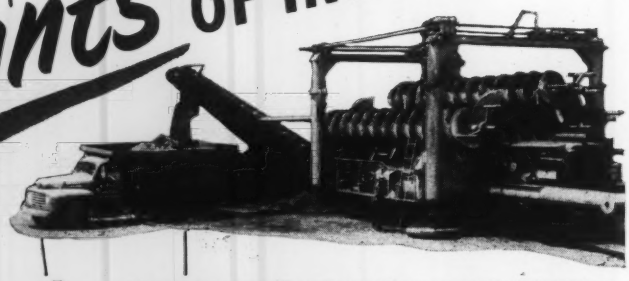
Electrol Actuating Cylinders use standard "O" ring packings, have a clevis type mounting and standard pipe ports. They can be used in either air or oil, with operating pressures up to 3,000 P.S.I., and are available in bore diameters ranging from ¾" up to and including 3". Your inquiry will receive prompt attention.

Electrol INCORPORATED HYDRAULICS
KINGSTON, NEW-YORK

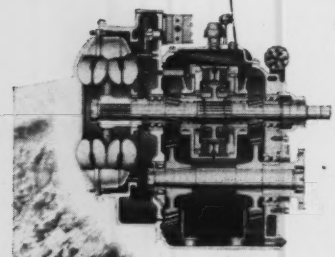
CYLINDERS • SELECTOR VALVES • FOLLOW-UP VALVES
CHECK VALVES • RELIEF VALVES • HAND PUMPS
POWERPAKS • LANDING GEAR OLEOS • SOLENOID
VALVES • ON-OFF VALVES • SERVO CYLINDERS • TRANSFER
VALVES • CUT-OUT VALVES • SPEED CONTROL VALVES

Better Designed Products Use Electrol Hydraulics

Giants OF INDUSTRY...



Exploit the "TWILIGHT ZONE"



When Compton Inc., Clarksburg, W. Va., developed its huge new 50-ton Compton Coal Auger, a Twin Disc Model 220 Hydraulic Coupling Reverse and Reduction Gear fitted the requirements for a shock-cushioned, quick reversing unit.

Combining two of Twin Disc's successful products—the heavy-duty, shock-absorbing Hydraulic Coupling, and the heavy-duty Reverse and Reduction Gear—the drive has been pronounced "highly satisfactory" by Compton officials, after prolonged production service.

The Auger cuts coal out of walls which heretofore were not exploitable—at such places as the barrier pillars between strip workings and old underground workings . . . the "Twilight Zone". Tests prove that it will repay its cost in a few months.

Such success in providing "the right connection" since World War I, plus the completeness of its line, plus an unmatched service system, have combined to make Twin Disc the world's largest manufacturer of industrial friction and fluid drives.

Hard-cutting, quick-stopping and reversing of this 52-inch—Model 56 Compton Coal Auger requires tough drive links—Twin Disc of course. Reaching 200' into the veins, it digs up to 700 tons per day.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

Built for a Long Life . . .
Backed for a Lifetime

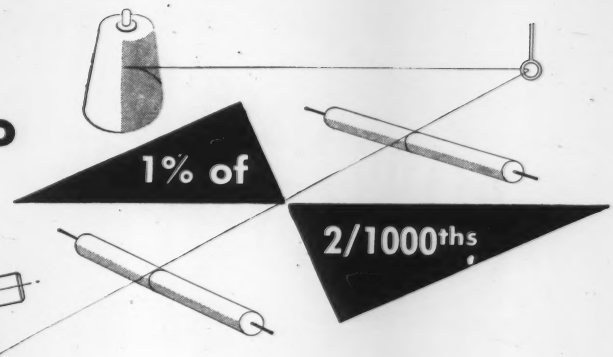
TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

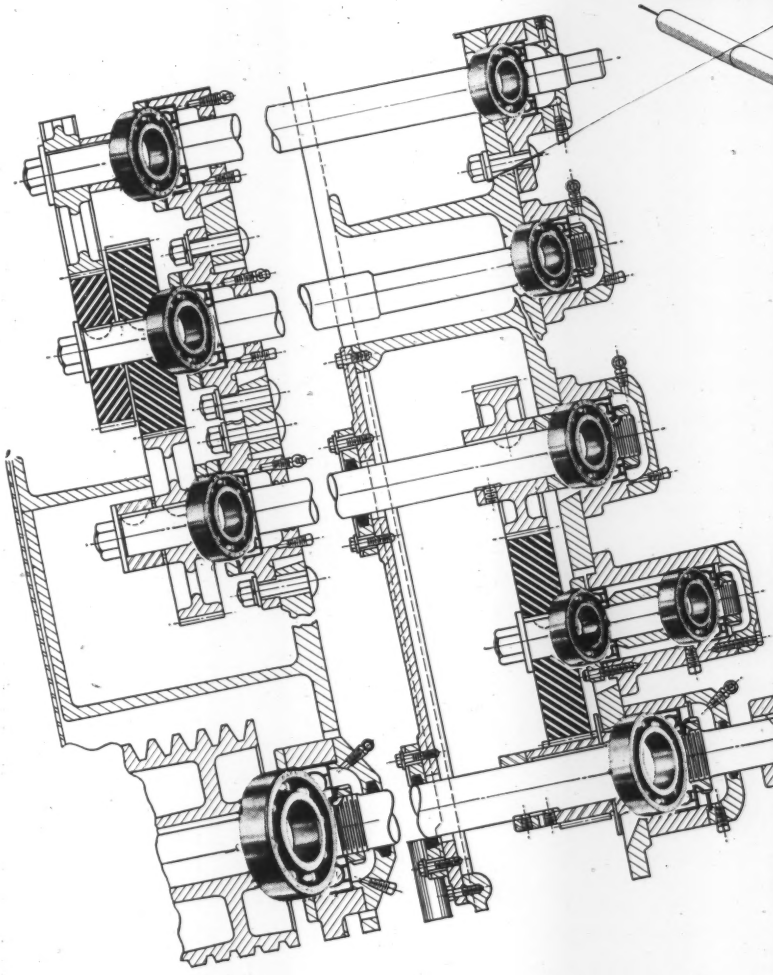
BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

Engineering News

Aluminum castings (before machining)
Aluminum forgings, pressings, and impact extrusions (before machining)
*Asbestos, amosite
*Asbestos, chrysotile, spinning fibers
*Asbestos, crocidolite
*Beryllium: Metal oxides, alloys, and compounds
Boron: Ferro-boron, boron metal, and all other alloys used as sources of boron
Calcium: Calcium-silicon, calcium manganese-silicon, and metallic calcium
Cerium:
Cerium metal, cerium alloys, such as ferro-cerium and cerium compounds in which cerium is a recognizable component.
All scrap and waste material containing commercially recoverable cerium of the above listed types
*Chromium: All forms of ferro-chromium and all other compositions containing more than 25 per cent chromium, which are used as sources of chromium in commercial manufacture or processing
Cobalt:
The element in any form and combination with other elements in which cobalt is an essential constituent (except cobalt concentrates, cemented carbide - tipped tools, cast cobalt-chrome-tungsten-molybdenum tools, and alloy hard-facing welding rods and materials; and except paints, varnishes, lacquers, inks, and similar products containing cobalt driers)
All scrap or secondary materials containing commercially recoverable cobalt
*Columbium:
Ferro - columbium, potassium columbium fluoride, columbium oxide, and columbium carbide
All scrap or secondary material containing commercially recoverable columbium of the above listed types
*Copper:
Refined copper (fire-refined and electrolytic) including refinery shapes such as wire bars, slabs, cakes, billets, and ingots
Secondary copper and copper-base alloys
Copper and copper-base alloys: alloy plate, sheet, and strip; alloy rod, bar, and wire (including extruded shapes); alloy tube and pipe; unalloyed rod, bar, and wire (including extruded shapes); unalloyed plate, sheet, and strip; unalloyed tube and pipe; copper and copper-base alloy castings; copper powder mill products
All copper and copper-base alloy scrap containing commercially recoverable copper.
Corundum, grain, and superfines
Graphite, artificial, electrodes and anodes
*Graphite, natural:
Crucible flake
Ceylon lump, 95 per cent and higher carbon
Iridium
*Magnesium:
Magnesium, primary and secondary ingots
Semifabricated shapes
All magnesium-base alloy scrap containing commercially recoverable magnesium
Manganese:
Manganese metal, ferro-manganese, spiegeleisen, and all other compounds and alloys which are used as sources of manganese in the manufacture of any alloy products
All scrap and material containing sufficient manganese to be of commercial value as an alloying agent
*Mica, muscovite block and film, good stained and better
*Mica, splittings, muscovite, and phlogopite
*Molybdenum: Pure molybdenum and ferro-molybdenum, all grades of molybdenum oxide, and all primary molybdates and other molybdenum compounds used as sources of molybdenum in commercial manufacture and processing
Nickel:
Nickel, alloyed or unalloyed
Imported nickel matte
Nickel and nickel alloy, metal (cathode nickel, pigs, shot, and other primary forms)
Nickel and nickel alloy, secondary
Nickel and nickel alloy, semifinished; bars, rods, tubes, sheet bar, ingot, blooms, billets, sheet strip, and similar mill products not further manufactured
All nickel and nickel-base alloy scrap and nickel silver scrap containing commercially recoverable nickel
Osmium
Platinum
*Rutile
Scrap, nonferrous, all types
Selenium
Silicon: All grades of ferro-silicon, including silvery iron or silicon pig; all grades of silicon metal; and all other compositions containing more than 6 per cent silicon, which are used as sources of silicon in the manufacture of any alloy products

SETUP
that holds tolerance to





Bearings used
Fafnir Extra-Precision Ball Bearings of the 200 (Light) and 300 (Medium) Series are shown in the ten locations above.

If you are familiar with machine designing, you'll consider this a "neat" piece of engineering. Such precision is actually achieved on mammoth synthetic thread twisters developed by Whitin Machine Works. The twisters stretch thread to a uniform .002 of an inch diameter and hold that diameter to within a 1% tolerance down a 40 foot line of spindles.

A sectional view of the head end which controls the "feed rolls" and "draw rolls" shows the Fafnir Ball Bearing setup that helps to keep their relative velocity absolutely constant . . . a "must" to produce such an amazing degree of accuracy. The Extra-Precision ball bearings used are made by highly trained operators on special equipment controlled by elaborate inspection devices.

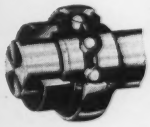
Whatever your bearing problem, a few minutes spent with a Fafnir representative may help you solve it equally as successfully. Fafnir's experience is not limited to just a few industries . . . it's industry-wide. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS

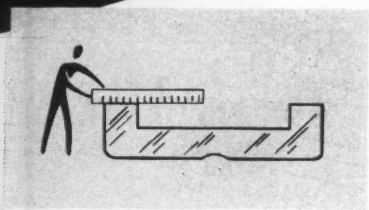
MOST COMPLETE LINE IN AMERICA

Standard Radial Ball Bearings

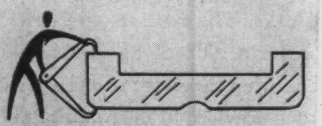
Power Transmission Units . . . all types and sizes


Wide Inner Ring Ball Bearings with Mechani-Seals

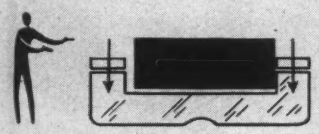
The Case of The Free Floating Cage



Guided by the wide, integral flanges

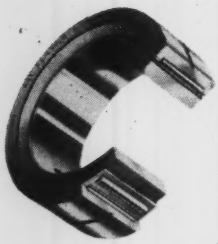


Flanges are thick, solid, really rugged . . .



To give fullest support to the cage

RBC's PITCHLIGN TRADE MARK ROLLER BEARINGS



PITCHLIGN bearings have a full length, free floating cage with *pitch circle contact!* Any tendency of the rollers to thrust is absorbed by the heavy integral flanges of the outer race. Completely relieved of this burden, the cage *cannot* distort and so fail in its vital duty of roller alignment. This is the one positive method of doing away with cocking and skewing. Only PITCHLIGN has it!

PITCHLIGN performs where others fail . . . interchangeable with precision needle bearings, of course. Get the facts! ***Ask for Bulletin SF-266***

RBC

ROLLER BEARING COMPANY OF AMERICA • TRENTON, N. J.

Engineering News

Talc, block (steatite)
*Tantalum metal and alloys, and all scrap and waste material containing commercially recoverable tantalum
*Tin:
Tin, primary and secondary
Tin, chemicals, including tin oxide
Tin products such as tin pipe and sheet
All alloys containing tin
All tin and tin-base alloy scrap containing commercially recoverable tin
Titanium:
Ingot
Semifabricated shapes
Sheets, tubes, extrusions
All grades of ferro-titanium, titanium metal and other alloys used to add titanium in the manufacture of any alloy products
All titanium-base alloy scrap
Tungsten:
Tungsten in any form or shape into which it may be fabricated; except such finished forms as are fabricated for installation (without further processing) into electrical communication systems, incandescent lamps, and electronic equipment such as radio, radar, and similar products
Tungsten, ferro, metal powder, and any other ferrous combination of the element tungsten in semimanufactured or manufactured form, excluding alloy steel, high speed steel, and tool steel
Tungsten, all nonferrous mixtures or alloys containing tungsten, prepared for any purpose requiring further processing, whether the same or manufactured by means of melting, pressing, sintering, brazing, soldering, or welding, including but not limited to mixtures or alloys to be used in the production of tools and tool blanks or as hard-facing materials; but not including any finished tools
Tungsten, all chemical compounds having tungsten as a recognizable and essential component
Tungsten, all scrap or secondary material containing commercially recoverable tungsten
*Vanadium: All forms of ferro-vanadium, vanadium pentoxide, and all other alloys and compositions used as sources of vanadium in commercial manufacture and processing
Zinc, slab (all grades)
Zirconium: Zirconium metal, ferro-aluminum-zirconium-silicon alloys, and all other metallic compositions used as sources of zirconium in the manufacture of any alloy products

Rubber Materials

*Natural rubber, dry
Synthetic rubbers, including latices, GR-S, butyl, neoprene, and N-types

The products which have been removed from the list include more than 20 items, from which the list following has been abstracted:

Chemicals

Carbon tetrachloride
Nylon, plastic type
Quinoline
Styrene
Thiokol polymers (name change only to alkyl polysulfide polymers)
Trichloroethylene

Metals and Minerals

Antimony, all forms
Bismuth
Cadmium
Lead, all forms
Zinc-base alloy in crude form
Zinc, dust and oxide
All zinc products such as rolled and extruded shapes, wire, and castings
Zinc and zinc-base alloy scrap containing commercially recoverable zinc

Leather

Hides and skins (domestic)

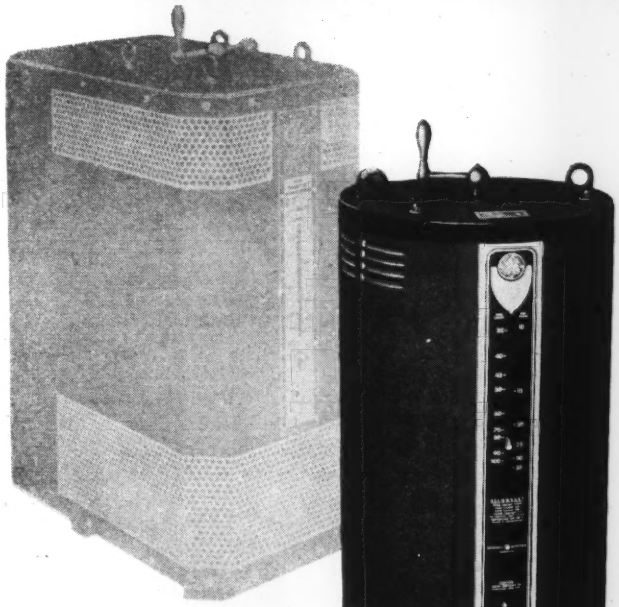
Rubber Materials

Natural rubber, latex

Copies of the complete revision of Designation 1 may be obtained from field offices of the Department of Commerce.

HOW G-E SILICONES OFFER YOU

IMPORTANT SAVINGS THROUGH NEW DESIGN POSSIBILITIES

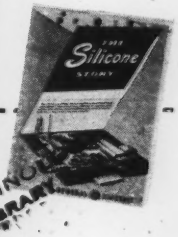


Lighter, more compact design! G-E silicones (resin SR-98) in Class H insulation made possible a 25% saving in critical copper in the redesign (right) of this atomic-hydrogen welder. G-E silicone insulation permits the welder to operate at higher temperatures—provides exceptional resistance to moisture and chemical fumes. Use coupon for more data on SR-98!

Here's an opportunity to save time, money and materials! Take advantage of the new design possibilities offered by General Electric silicones. For example, new Class H insulation made with G-E silicones permits drastic reductions in the size and weight of aircraft autotransformers. G-E silicone rubber makes possible longer-lasting jet engine seals, diesel gaskets and aircraft ducting.

WHAT CAN G-E SILICONES DO FOR YOU?

New design possibilities of silicones are suggested in an informative booklet *The Silicone Story*. Why not write for a copy today? In it you may find the key to improving a product or process . . . possibly even a clue to making an entirely new product! Just mail the coupon.



General Electric Company
Section 31-6B
Waterford, New York

☐ Please send me a free copy of *Silicone Story*.
☐ Send me product data on SR-98.

DEPARTMENT OF TECHNOLOGY
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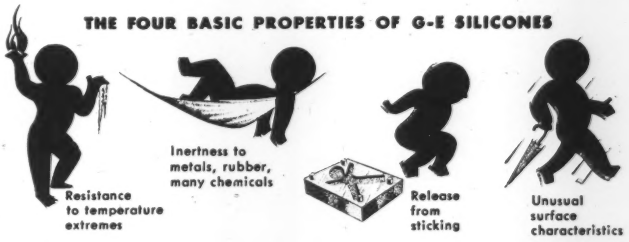
(In Canada, mail to Canadian General Electric Company, Ltd., Toronto.)

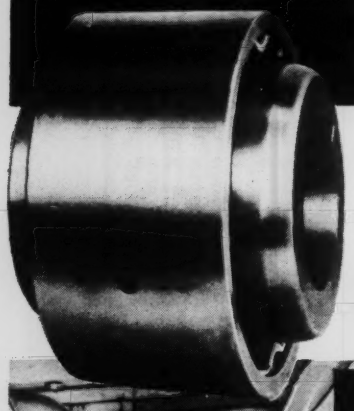
THE FOUR BASIC PROPERTIES OF G-E SILICONES


Resistance to temperature extremes
Inertness to metals, rubber, many chemicals
Release from sticking
Unusual surface characteristics

G-E SILICONES FIT INTO YOUR FUTURE

GENERAL ELECTRIC

131-6

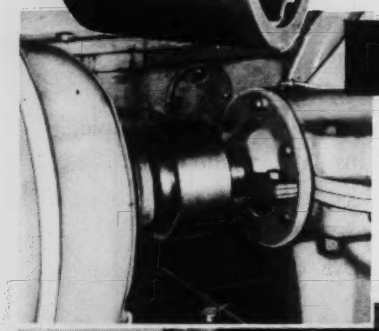


Cut Down-Time, Coupling Losses

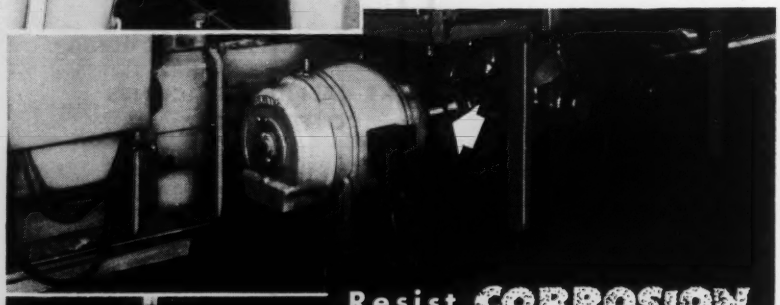
with **Sier-Bath** *Flexible*

GEAR COUPLINGS

Resist SHOCK



• Photos show a Size 4½ Standard Type Sier-Bath Coupling installed on the main drive of a Tube Reducer with a 75 HP AC 1200 RPM motor. Torque is very high, with bad shock conditions. The user reports: "Sier-Bath Couplings are the only couplings we've been able to keep on this job"!



Resist CORROSION

• Unretouched photo shows a Size 4½ Standard Type Sier-Bath Coupling installed over a pickling tank. As the shaft is started with a dead weight load, the coupling transmits extremely high torque. Notice the coupling's exterior corrosion. The interior remains untouched, and ease of uncoupling is unaffected.

ONLY 7 PARTS! Powerful one-piece sleeve has no bolts to shear, seize, strip or corrode—neoprene seals keep in lubrication, seal out chemicals, water, etc. Assembled and uncoupled in *seconds* —even after the severest exposure to corrosion! Smaller, lighter—have lower moment of inertia, put less strain on shafts, bearings. To find out more,

WRITE FOR BULLETIN. Gives installation photos, advantages, specs for standard, vertical, mill motor and floating shaft types—sizes from ⅜ to 6, HP 4 to 600. (Special types and sizes on request.)

Founded 1905

Member A.G.M.A.

Sier-Bath GEAR and PUMP CO., Inc.

9245 HUDSON BOULEVARD, NORTH BERGEN, N. J.

Also Manufacturers of Precision Gears, Screw and "Gearex" Rotary Pumps

Stress Relief

SINCE J. P. Henderson started on his course of improving engineering department deportment, we've been waiting for someone to give him his comeuppance. Because J. P. garnered his freely dispensed wisdom in the position of Chief Engineer, the following contribution has its little irony.

To the Editor:

The Detail Engineer so aptly set forth in "Stress Relief," May issue, is, of course, a familiar hapless figure around most organizations.

However, as I read about our noddle-headed friend, I could not help but think of his counterpart, the No Detail Chief to whom, I suspect, your readers need no introduction, either. Firkin in our story knows him, oh, so well.

—A READER

The No Detail Chief
A Modern Tragedy

Scene: Private office of THE CHIEF.

Time: Any time.

Firkin, a minion, is addressing THE CHIEF.

FIRKIN (*knuckling his forehead*): Firkin reporting on Model XX, sir.

CHIEF: Yes, yes Firkin. But remember, not a lot of details.

FIRKIN: Yes sir, I mean, no sir.

CHIEF: All right, Firkin, ready, begin.

FIRKIN: Came through last week. Now on test. Shows some evidence of excessive wear and may need some modification.

CHIEF: Is that all, Firkin?

FIRKIN: Well, yes sir.

CHIEF: How about that funny experience we had when Model XX came through Dept. 87A last week?

FIRKIN: But, sir, you said . . . .

CHIEF: Please, Firkin, no unimportant details. Just give me facts, facts. If I hadn't heard about this

Baldor

Better MOTORS

WHY BUY OPEN MOTORS WHEN BALDOR TOTALLY ENCLOSED MOTORS cost no more?

Baldor STREAMCOOLED Motors are solidly enclosed . . . externally ventilated, fan-cooled, non-clogging . . . dust-proof, splash-proof, lint-proof.

Corrosion-resistant and especially impregnated to resist moisture. Standard NEMA dimensions.

ASK FOR FACTORY DATA on our complete line of electric motors, (1/20-20HP).

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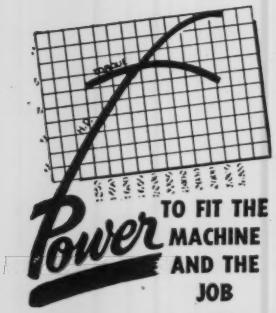
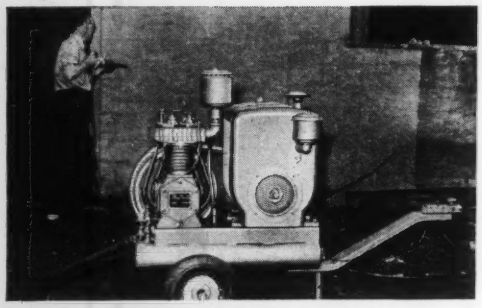
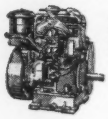


Power TO FIT THE MACHINE AND THE JOB



WISCONSIN-POWERED
Gardner-Denver Compressor

4-cycle Single Cyl. 3 to 9 hp.



4-cycle 2-Cyl. 7 to 13 hp.

V-type 4-Cyl. 15 to 30 hp.

This Model TP0493LE Portable Compressor, made by Gardner-Denver Co., Quincy, Ill., is supplying air for the operation of a Model S17 Utility Drill, engaged in a plant maintenance job. Complete power reliance is placed on the Model TF 2-cylinder Wisconsin Heavy-Duty Air-Cooled Engine.

More and more builders of engine-driven equipment are discovering, to the satisfaction of themselves and their customers, that you can't do better than to specify "Wisconsin Engines"... for dependable power to fit both the machine and the job.

Available in a complete power range from 3 to 30 hp., in 4-cycle single cylinder, 2-cylinder and V-type 4-cylinder models, Wisconsin Air-Cooled Engines provide economical power, without waste, to meet the most exacting requirements. Look into them for your use.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

4 STAR TIMER

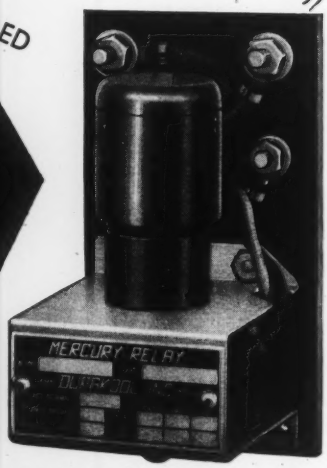
- ★ No false contacts
- ★ No chatter
- ★ Quiet in operation
- ★ Eliminates double contacting or breaking of circuit

HYDROGEN PACKED

Durakool
STEEL MERCURY TIMERS

The steel-clad "fixed time" Durakool timer-relay operates in "sealed in" hydrogen under pressure, with mercury to mercury contacts. Timing is tamperproof. Non-breakable and built for millions of contacts. Fixed time delays available from 1/6 to 20 seconds, either normally open or normally closed action.

See Telephone Directory for Local Distributor or write Durakool, Inc. Elkhart, Indiana



Send for Bulletin 800

Stress Relief

from Joe Clobber I'd probably not have known anything about it. Facts, Firkin, facts!

FIRKIN (*quavering*): No sir, I mean, yes sir.

CHIEF: The engineering department'll very likely end up by having to show Joe Clobber how to run his department. It always happens. The brass hats probably think we don't have enough to do around here. Well, Firkin, anything else?

FIRKIN: W - - --

CHIEF (*cutting him off in the middle of a monosyllable*): Nothing else, eh? How about that little belt slipping episode during the laboratory test? Didn't think I knew about that, eh? Oh, I still get around, Firkin, maybe a little faster than some of you so-called young fellas. What's the matter with those long hairs down in that laboratory, anyway? Don't they know how to run a simple test? And the maintenance department —don't they know how to set up a machine so the belts won't slip? And those belts and belt dressing —are they in accordance with the drawings and specifications or did the purchasing department buy something out of the classified directory again? How many departments in this company do we have to run, anyway?

FIRKIN: Yes sir, I mean, no sir.

CHIEF: Well, Firkin, that'll be all. Guess we'll just have to carry on as we always have.

FIRKIN: Yes, sir.

CHIEF: But one thing, Firkin. Try to make these reports without a lot of details. In this case all you had to tell me was—came through last week, now on test, shows some evidence of excessive wear and may need some modification—something like that. I can't clutter up my memory with a lot of details.

FIRKIN (*slinking away*): Yes sir.

Curtain

By the way, the author of this everyday drama refuses to by-line it. As assistant to the president of well known company, he "suggests that in order to avoid any possible misunderstanding, he be referred to simply as A READER in the event of publication."

Reynolds
ALUMINUM REPORTER

★ ★ ★ Tenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

FORMING TECHNIQUES MODIFIED WITH ALUMINUM

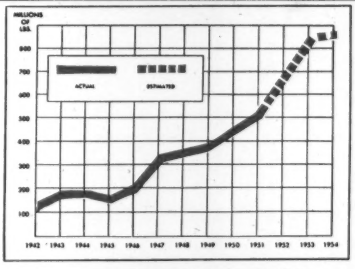
Aluminum Offers Greater Conductivity Per Dollar in the Electrical Field

In this field, it is electrical conductivity that counts, not the weight or volume. And in this respect, it's of real interest to know that a recent cost comparison shows every pound of aluminum saves $0.31 compared with the cost of copper of equal conductance. It is this saving of almost two-thirds in material cost that is focusing the attention of the entire electrical industry on aluminum.

It is interesting to note that overhead transmission lines are now almost 100% aluminum; rural distribution is mostly with aluminum; and aluminum for city distribution, telephone cable and bus conductor is rapidly being adopted. Aluminum is also acceptable and now being tried for insulated building wire and power cable, for automotive wiring, and magnet wire applications.

Rapidly increasing production of aluminum and unequalled abundant ore resources make the outlook increasingly bright for a greatly expanded use of aluminum in the electrical field in the coming years (see chart below).

STILL MORE ALUMINUM COMING



The expanding primary aluminum production of Reynolds Metals Company . . . a historic chapter in the company's 33 years of continuing growth.

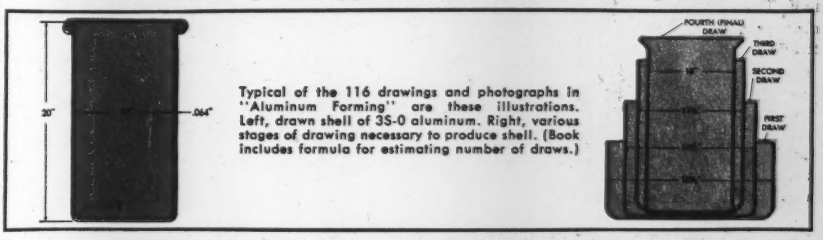
Reynolds Technical Specialists are available for assistance on specific electrical applications of aluminum. For information call the Reynolds office listed under "Aluminum" in your classified telephone directory or write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

New, Light Aluminum Crutch

A new, vastly superior aluminum and wood crutch is now on the market. According to the manufacturer, Pioneer Crutch and Cane Company, Lisbon, Ohio, the use of aluminum is far more economical despite a slightly higher raw material cost. This new, adjustable crutch requires only three or four manufacturing steps against twenty steps for the construction of an old-time, all-timber crutch.

Designer's Selection of Alloy and Temper Affects Production Costs, Product Efficiency

For some applications, design and fabrication practices with aluminum are similar to those used with other metals. In many cases, however, modifications and possibly even special procedures are required. Selecting the proper grade of aluminum for each specific application is also of utmost importance.



Typical of the 116 drawings and photographs in "Aluminum Forming" are these illustrations. Left, drawn shell of 3S-0 aluminum. Right, various stages of drawing necessary to produce shell. (Book includes formula for estimating number of draws.)

To acquaint design engineers and plant supervisors with the proper techniques for working aluminum, Reynolds has just released a new handbook, "Aluminum Forming". This latest addition to Reynolds Technical Library of informative literature is a 148 page, 6" x 9" book. It is clearly illustrated with 116 drawings and photographs and has many valuable tables.

"Aluminum Forming" is divided into four major sections. Section I is devoted to metallurgical and technical data pertaining to aluminum sheet . . . data essential for designing and fabricating aluminum sheet products.

Section II covers various types of sheet forming operations. Included is data on shearing and slitting, blanking and piercing, hole flanging, bending and pressing, rubber forming, continuous roll forming, drawing and ironing, bulging, necking, curling, beading and roll flanging, drop hammer forming, stretch and contour forming, embossing and coining, stamping and spinning.

Section III presents data on aluminum tubing and pipe comparable to that in the first section on sheet. Section IV discusses the forming, bending and swaging of aluminum tubing and pipe and includes information on machine, press, stretch, roll and hand forming methods.

In case of special aluminum forming problems, Reynolds also offers the services of its trained staff of aluminum specialists. They are available to work with manufacturers on aluminum designs and to help set up for fast, economical production. For prompt service, call the Reynolds office or distributor listed under "Aluminum" in your classified telephone directory, or write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.

For your free copy of the valuable handbook described above, plus a complete index of Reynolds technical literature, write on business letterhead (otherwise price is $1.00) to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

New Aluminum Diffuser Offers Simple, Efficient Control of Air Flow

A new diffuser with an exclusive adjustment feature has been developed by J.M. Marr of the Aladdin Heating Corporation, Oakland, California. This diffuser, provides a controlled variable air pattern that can be adjusted to any angle of discharge from horizontal to vertical flow. Adjustments are simple, require no tools and can be made easily by the finger tips. A turn of only 11½ degrees covers the complete range from horizontal to vertical flow. On the face plate, the slotted pieces are folded back to act as deflection fins; the other plates are completely blanked out.

From a manufacturing standpoint, aluminum was chosen for this diffuser because it is easy to blank, form and handle in production. Also, it aids in prolonging tool life. From a sales standpoint, aluminum offers a rustproof, stainproof surface which presents an attractive appearance in its natural form to harmonize with all color combinations. This also helps keep costs down.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

(Advertisement)

Printed in U.S.A.

(Continued From Preceding Page)

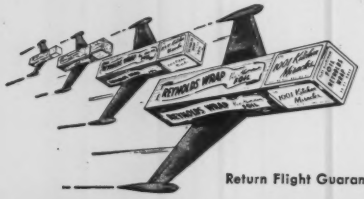
Aluminum Foil Cuts Ironing Drudgery, Adds Big Sales Building Feature

Here's an application where the high heat reflectivity of aluminum really pays off! Wise thinking on the part of the Merkin Company, Boston, Mass., led to the development of their new "FOILIN" ironing board pad that employs an inner liner of Reynolds Aluminum foil between two layers of cotton wadding.

The aluminum foil reflects heat from the iron back into the work. This irons the work drier and irons it faster . . . actually cuts ironing time in half. The cotton wadding provides a multitude of small air spaces that permits heat to "bounce" back from the aluminum. Thus heat is applied to the work from both sides, resulting in much greater ironing speed.

The Reynolds Aluminum foil used in the "FOILIN" ironing board pad is stitched and handled as easily as the cotton materials, so operations in the stitching and cutting room are greatly simplified. Also, each pad actually uses only a small amount of foil, so that the cost of material is exceptionally low on a unit basis. The usefulness of the pad will not decrease, as the aluminum will retain its great heat reflectivity almost indefinitely. Tests have shown that ordinary conditions of use such as encountered here do not decrease the reflectivity more than a few percent over many years of use. Also aluminum is immune to rust, rot, mildew and insects.

For information on Reynolds Aluminum foil and its possible applications in your products, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.



Return Flight Guaranteed.

New Piasecki HUP Helicopter Designed To Carry Out Many Essential Duties in Navy Shipboard Service

Reynolds Aluminum Used for Strength, Weight Saving and Ease of Fabrication

More wings for the Navy now are being delivered in the form of a tandem rotored helicopter, the HUP, made by Piasecki Helicopter Corporation, Morton, Pennsylvania. The HUP is equipped with an automatic pilot and is a 6-place model designed for shipboard service. It will be used by the Navy aboard Fleet carriers and cruisers for plane guard rescue, anti-submarine patrol and ferrying personnel and cargo between ship and shore.

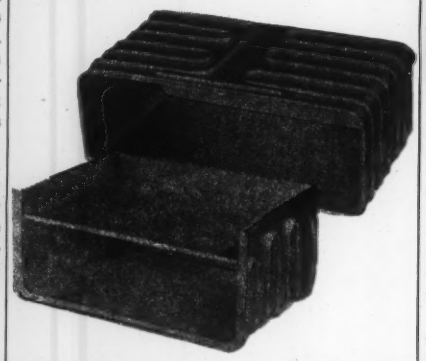
In speed trials, a prototype of the streamlined HUP made calibrated runs at 131 miles per hour. This high speed, plus a fast rate of climb, is basically due to relatively low structural weight in relation to available power. And Reynolds Aluminum is used to help achieve the favorable weight-power ratio. In addition to providing light weight with strength, the rigid, all-metal fuselage has curtailed vibration in the Piasecki HUP.

Merchant and Evans Company, Reynolds distributor of Philadelphia, supplies Piasecki Helicopter Corporation with aluminum. Merchant and Evans also supplies Reynolds Aluminum sheet, strip, wire, rod, bar, tubing and structurals to other leading manufacturers in many diversified fields. To locate your nearby Reynolds office and distributor for fast service on design and production problems, look under "Aluminum" in the classified telephone directory.

Reynolds Offers Complete Fabricating Service for Aluminum Parts

Bright, color-anodized aluminum refrigerator shelving, door trays and crisper pans, plus evaporators and home freezer liner panels are examples of parts mass-produced by Reynolds Aluminum Fabricating Service to quality standards exceeding industry requirements.

The many advantages of aluminum are clearly demonstrated in the Reynolds fabricated evaporators shown below. No other material offers the serviceability of rustproof, stainproof, light yet strong aluminum. No other material offers a better combination of economy and efficiency in rapid heat conduction. Reynolds embossed aluminum sheets add to evaporator rigidity, provide surfaces that resist scratching.



Reynolds will be glad to work with you on your requirements for aluminum blanks and parts, or on development work for future application. Contact the nearby Reynolds office listed under "Aluminum" in your classified telephone directory, or write Reynolds Metals Company, Parts Division, 2065 South Ninth Street, Louisville 1, Kentucky.

Aluminum Carts Speed-up Handling, Reduce Breakage of Costly TV Tubes

Ten out of eleven major TV tube manufacturers are now relying on aluminum push carts made by Bucks County Enterprises, Inc. of Quakertown, Pennsylvania, to transport precious picture tubes within their plants.

These aluminum carts replaced the cumbersome plywood and angle iron equipment formerly used. Lightweight aluminum speeded up handling and reduced tube breakage. Upkeep is no problem as aluminum is rustproof, decay proof and corrosion resistant. Ease of operation of these carts also helps in keeping down labor turnover in departments where the carts are used.

Printed in U.S.A.

(Advertisement)

Design Abstracts

(*Continued from Page* 185)

the selection of the most suitable welding process, is the joint design. For most designs there are four basic joint types, as shown in *Fig.* 1. They are: butt joints, lap joints, fillet joints, and edge joints. Overlay welding should also be included.

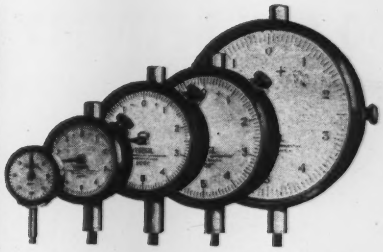
These basic joint designs can only be used with certain welding processes. For example a lap joint cannot be used for flash welding, or a fillet type of weld cannot be made by resistance welding. The recommended processes for various joint designs are shown in TABLE 2. This table shows which basic joint designs are applicable to the various processes and thicknesses of material.

Production Rate: This factor has an important bearing on the selection of the most economical welding process. The resistance welding processes, where applicable, offer the greatest economy when the production rate justifies the cost of the welding equipment. Flash welding equipment machines may cost from a few thousand to a million dollars, and unless the production rate is high, the cost per unit cannot be justified. Many products may require a redesign if the production rate is sufficiently high to justify lower cost of welding by adaptation of special automatic welding processes.

Power Availability: The power supply has a bearing on the selection of the welding process, since with certain welding processes an adequate amount of electrical power supply must be available. For large resistance welding machines, the power source must be adequate to meet the high current demands. Where electric power is not available, portable power generating units can be employed or welding processes can be used which do not depend on electric power.

Economics of Process: This fac-

Need a Special Gage?



Dial Indicators for every gaging requirement—over 80 different models, ranges, sizes, graduations, styles.

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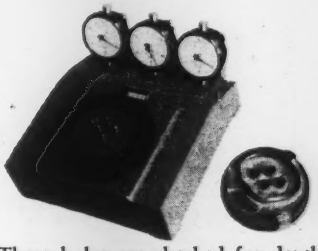
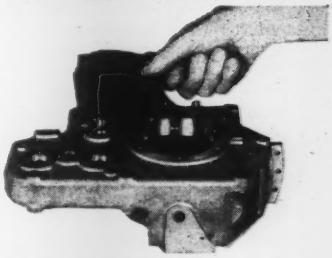


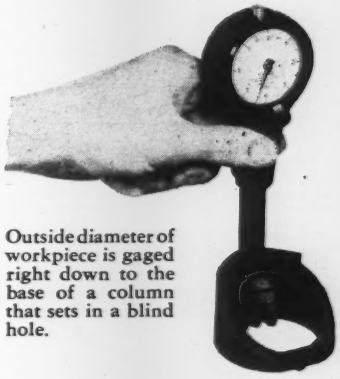
Three holes are checked for depth simultaneously, to accuracy of .0005".

If you've tried designing and building your own dimensional gages you probably know how costly and unsatisfactory such "homemade" gages can be — not only to *make* but to *use!*

Don't waste time and money tediously duplicating designs which already exist in our file of over 25,000 gage designs. Bring your gaging needs to Federal and take advantage of our practical and long experience in this field which can't be equalled anywhere in the world. We will gladly work closely and confidentially with you on your dimensional gaging requirements. Send full details and blueprints to Federal Products Corporation, 1308 Eddy St., Providence 1, R. I.



Position of small hole as well as distance with reference to large hole is inspected on this housing.



Outside diameter of workpiece is gaged right down to the base of a column that sets in a blind hole.

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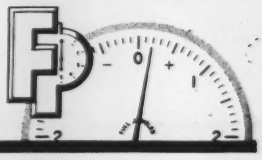

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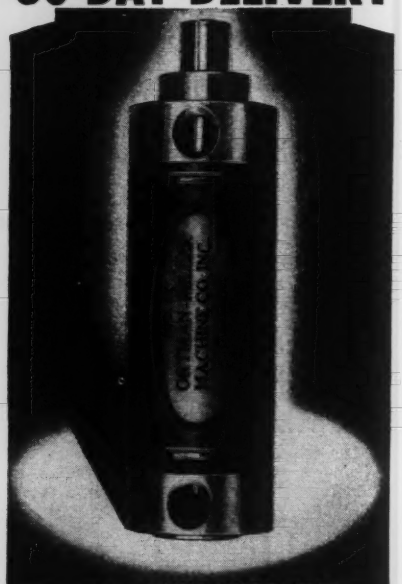

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Design Abstracts

tor is of greatest importance in the selection of the most suitable welding process, since the basis of selection is for the most economical process or method of welding which will produce a product that will fulfill the service requirements adequately. The cost of a welding process will depend upon the following factors:

1. Preparation
2. Setup operations
3. Welding
4. Equipment
5. Finishing.

With present inflationary trends and with high labor costs, it is of utmost importance to select welding processes which can be made with the minimum amount of labor, or if possible, substitute automatic welding operations which will require little or no training of the welding operators.

Relative Costs

In *Fig.* 2, the relative cost per unit including material, labor, power, and equipment costs for five different welding processes is shown graphically. It will be noted that for some of the processes, namely the covered electrode, the labor cost is probably the largest factor in the unit cost of welding. In submerged-arc welding, material cost is the largest factor in this comparison . In inert-gas metal-arc welding, the cost of material is the highest single factor. In flash welding, equipment cost is the largest factor. In thermit welding the labor and material costs are the large items.

The distribution of welding costs per unit is only for comparison purposes to illustrate the relation of labor, material, power, and equipment costs. The distribution chart for the types of welding processes shown indicates that the cost of material, labor, power, and equipment varies widely with the different processes.

In the past, welding engineers and design engineers have not given sufficient thought to redesign for the most economical process. The possibilities for further reduction in welding costs in the fu-

"Joe, how can we save money on these small parts?"
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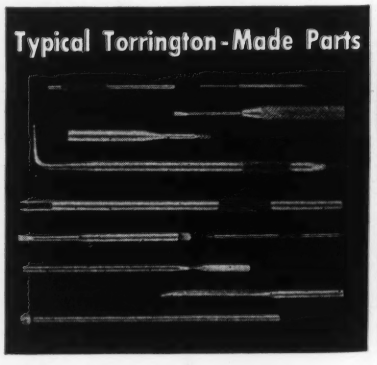
When it comes to holding the line on costs—and holding strict tolerances at the same time—it takes experience and facilities. For over 86 years, Torrington has been making precision metal parts. Production facilities include batteries of automatic and semi-automatic machines—many of them Torrington-designed—and one of the finest heat-treating departments in the world. In addition, we have at our disposal the combined experience and facilities of all 11 plants of The Torrington Company.

If you need precision metal parts, ask us for a quotation. Just send us a sample or blueprint and tell us how many you need.



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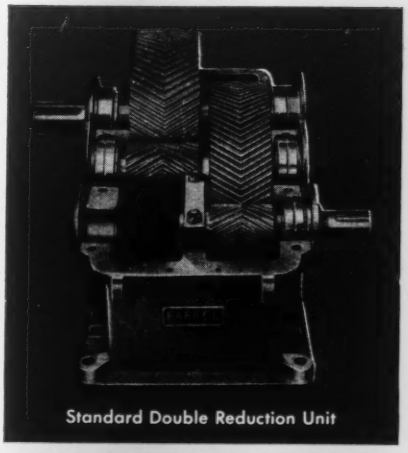
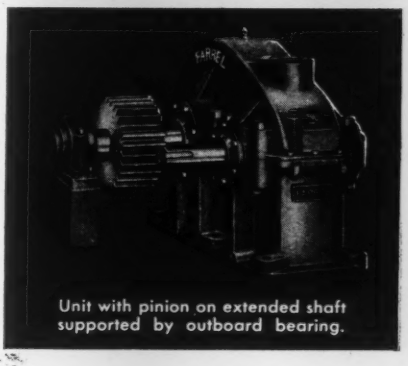
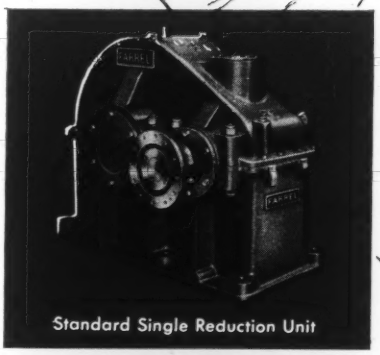
FIVE ANSWERS TO SPEED REDUCER PROBLEMS



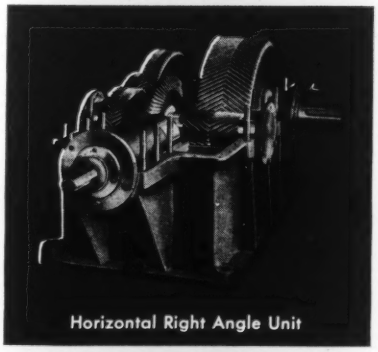
Standard Double Reduction Unit



Unit with pinion on extended shaft supported by outboard bearing.



Standard Single Reduction Unit



Horizontal Right Angle Unit

Heavy Duty Single Reduction Unit

Farrel speed reducers are made in a number of different types, with a wide range of ratios and capacities. Designs include single, double and multiple reduction units, speed change units having two or more selective speeds, right angle drives, and drives to meet special requirements.

All units are supplied with precision gears, generated by the famous Farrel-Sykes process for smooth, quiet, efficient power transmission; shafts and bearings factored to safeguard against interruption of vital processes; gear cases proportioned to withstand repeated heavy peak loads; joints sealed to prevent entrance of dirt.

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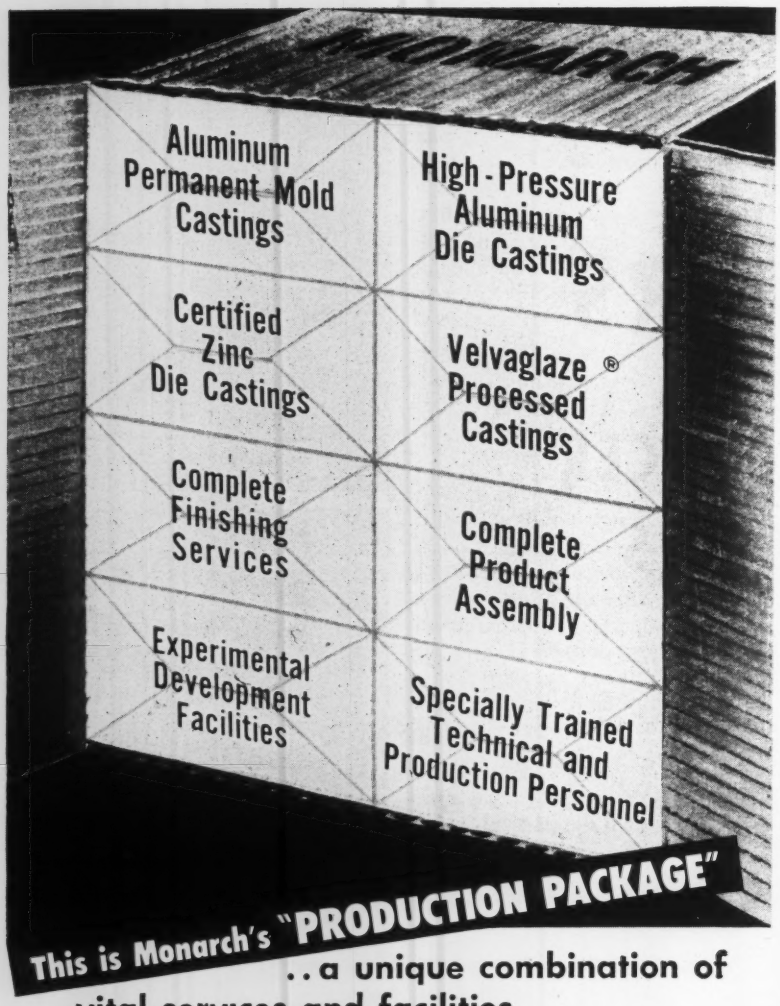

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ture will depend to a large extent on the redesign of welded products, in order that the most economical process can be selected. Further research investigations will undoubtedly result in improvement in the present welding processes and may stimulate new inventions for more economical welding processes.

From a paper entitled "Factors in the Selection of Welding Processes" presented before the Summer Meeting of the SAE in Atlantic City, N. J., June 1952.

Automatic Control of Variable-Speed Drives

By Henry G. Keller
Link-Belt Co.
Philadelphia, Pa.

FOR the semiautomatic or full automatic operation of variable-speed drives, a great variety of control schemes may be applied. Most control schemes consist of three elements. There is a unit which is capable of transmitting a minute impulse, a receiver which can then resolve the requirement and, finally, a relatively powerful actuater which can change the ratio of the transmission. For more descriptive terms we can call the initial unit the signal, the second unit the brain, and the final unit the brawn. Signal, brain, brawn—this is the manner and order in which they function.

Signal devices are available that are actuated by speed, motion, temperature, voltage, pressure, vacuum, light, torque, tension, etc. Basically the signal device either produces a small mechanical motion, or controls an electrical circuit. The transmission of the signal to the brawn unit may be electrical, hydraulic, mechanical, or a combination. When the signal indicates a need for a ratio change, the brain unit resolves the need and causes the brawn unit to function. The brain and brawn units may be electrical, hydraulic or pneumatic, or a combination as determined by the signal device and the operating requirements under which the brawn unit must function. Hydraulically controlled units

Speed Nut Savings Stories

The Glenn L. Martin Company leads the way to...

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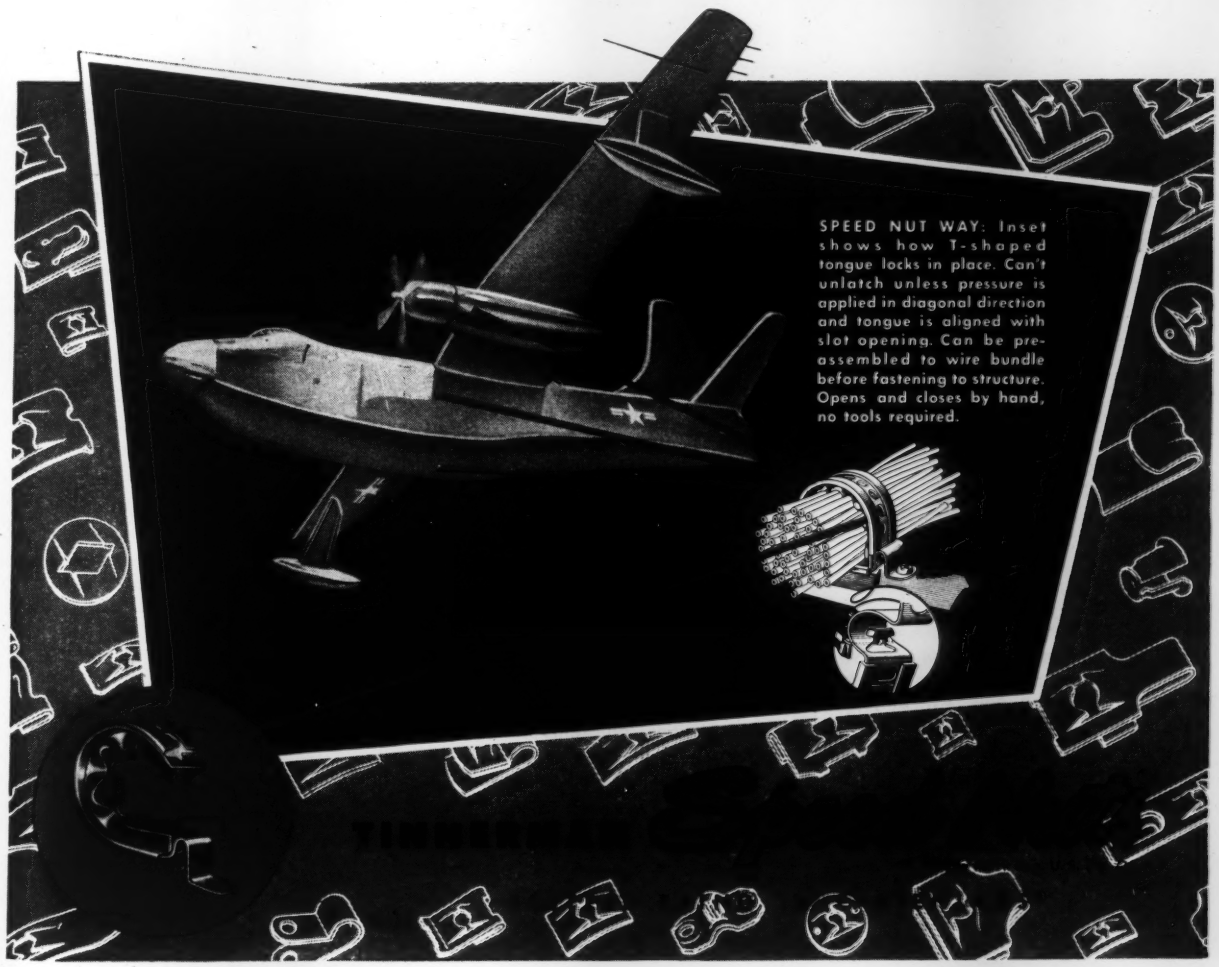
The new TINNERMAN Electrical Harness Clamp "takes off" on really big-money savings for the Glenn L. Martin Company, builder of the famous Martin Bombers. Aircraft designers and engineers at Martin found that in a quantity such as 1000 planes, a savings of $270,000 could be made... or 18 cents per clamp over former methods for 1500 clamp installations in the new Martin P5M-1 Marlin! Think of this tremendous savings in terms of the thousands of aircraft on order for building America's defenses—and you see how "multi-million-dollar savings" can be made for conversion into even greater production!

Tinnerman engineering reports this significant savings story to all American industry as another example of Tinnerman teamwork! For better fastening analysis and engineering know-how... for significant production savings no matter what your fastening problem, turn to TINNERMAN! There's a Tinnerman representative in your area to give you competent help... he'll be happy to supply details for a FASTENING ANALYSIS of your product. Meantime, write for your copy of SPEED NUT "Savings Stories": TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners, Ltd., Hamilton. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A.—7 rue Henri Barbusse. Levallois (Seine) France.

Whatever you build—from Aircraft to Clothes Dryers—Think first of Tinnerman for better fastening Engineering!


SPEED NUT WAY: Inset shows how T-shaped tongue locks in place. Can't unlatch unless pressure is applied in diagonal direction and tongue is aligned with slot opening. Can be pre-assembled to wire bundle before fastening to structure. Opens and closes by hand, no tools required.

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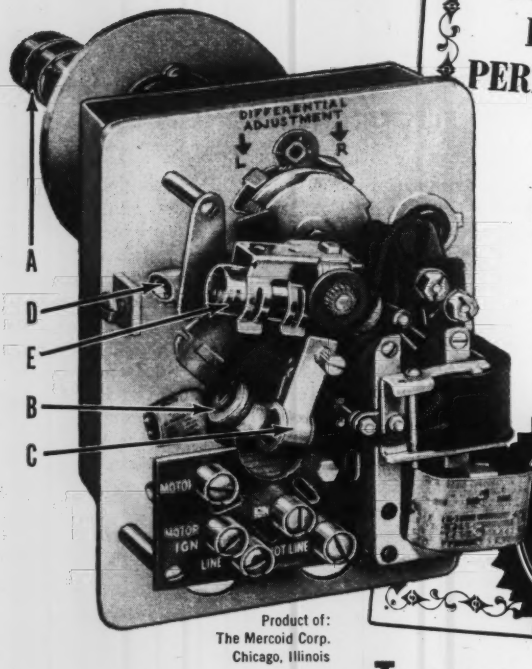

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During normal operation, the rise in stack temperature will actuate bimetal coil "A" in the stack and cause heater coil "B" to move away from bimetal loop "C" and open ignition switch "D" Should ignition fail to occur when the burner is started, heater coil "B" remains within bimetal loop "C" as the stack temperature does not rise. The current flowing through coil "B" heats up the bimetal loop "C" and stops the burner after the predetermined time has elapsed for which the safety has been set. In the event of flame failure, the stack temperature lowers causing the heater coil "B" to move into bimetal loop "C" and after predetermined time, safety switch "E" releases and stops the burner.

If the actuating element of your new control device is thermostatic bimetal, Chace can furnish it completely fabricated, ready for assembly. Our 29 types of bimetal are available in strips, coils, random long lengths and welded or brazed sub-assemblies. Before proceeding with your next design, consult our application engineers, recognized authorities on temperature responsive devices, or write today for our new 32-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing condensed engineering data.

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Design Abstracts

usually require a motor-driven hydraulic pump, whereas pneumatically controlled units operate on plant air pressure whenever it is available.

Occasionally it is possible to eliminate the brain unit and go direct from signal to brawn, for in some cases where materials are strong and the working loads are high the signal is strong enough to operate the brawn unit direct.

Time Lag Compensation

All controls are of the follower type, hence when something gets out of balance, a signal attempts to do something about the ratio variance. The signal needs to have only sufficient strength to register the unbalance at the brain unit. It takes only a split second to send a signal, a moment for the brain unit to receive and resolve the signal, and a little while to make the correction through the brawn unit. The time lag involved in many cases requires a suitable means to collect or pay out the portion of the material or process as necessary during the off-ratio period.

Quite often the collect or pay out function is accomplished by a floating roll or arm; in other cases a loop of material between the various process steps provides the required time lag.

Semi-automatic or automatic controls are available in various designs involving electrical, hydraulic, pneumatic and mechanical equipment which may be outlined as follows:

CONTROL ELEMENT →	SIGNAL	BRAIN	BRAWN	CONTROL CHARACTERISTICS
CONTROL FUNCTION →	DETECTION	ANALYZER AND AMPLIFIER	CHANGES THE RATIO	
CLASS A	CONTINUOUS FLOATING	ON OFF	SINGLE SPEED	HUNTING
CLASS B	CONTINUOUS FLOATING	ON OFF WITH INTERRUPTER	SINGLE SPEED PULSING	HUNTING
CLASS C	CONTINUOUS FLOATING	PROPORTIONAL	VARIABLE RESPONSE RATE	DAMPENING
CLASS D	USUALLY OMITTED	USUALLY OMITTED	USUALLY MECHANICALLY DRIVEN	POSITIVELY DRIVEN

While the time for response of control systems may vary consider-

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Design Abstracts

ably, it should be recognized that all controls follow the same pattern except possibly the slip clutch, which in effect is not a control, but just slip which is governed by tension and/or torque. As applied to variable-speed drives, types A and B have a floating signal element that has three bands: fast, slow, and central dead bands. Beyond the normal extreme limits of travel, safety bands may be required. The chief difference between A and B is that B includes an interrupter device which reduces the amount of correction time—the interrupter produces a pulsing action to the brawn unit and thus acts to reduce the hunting effect.

Variable Response Control

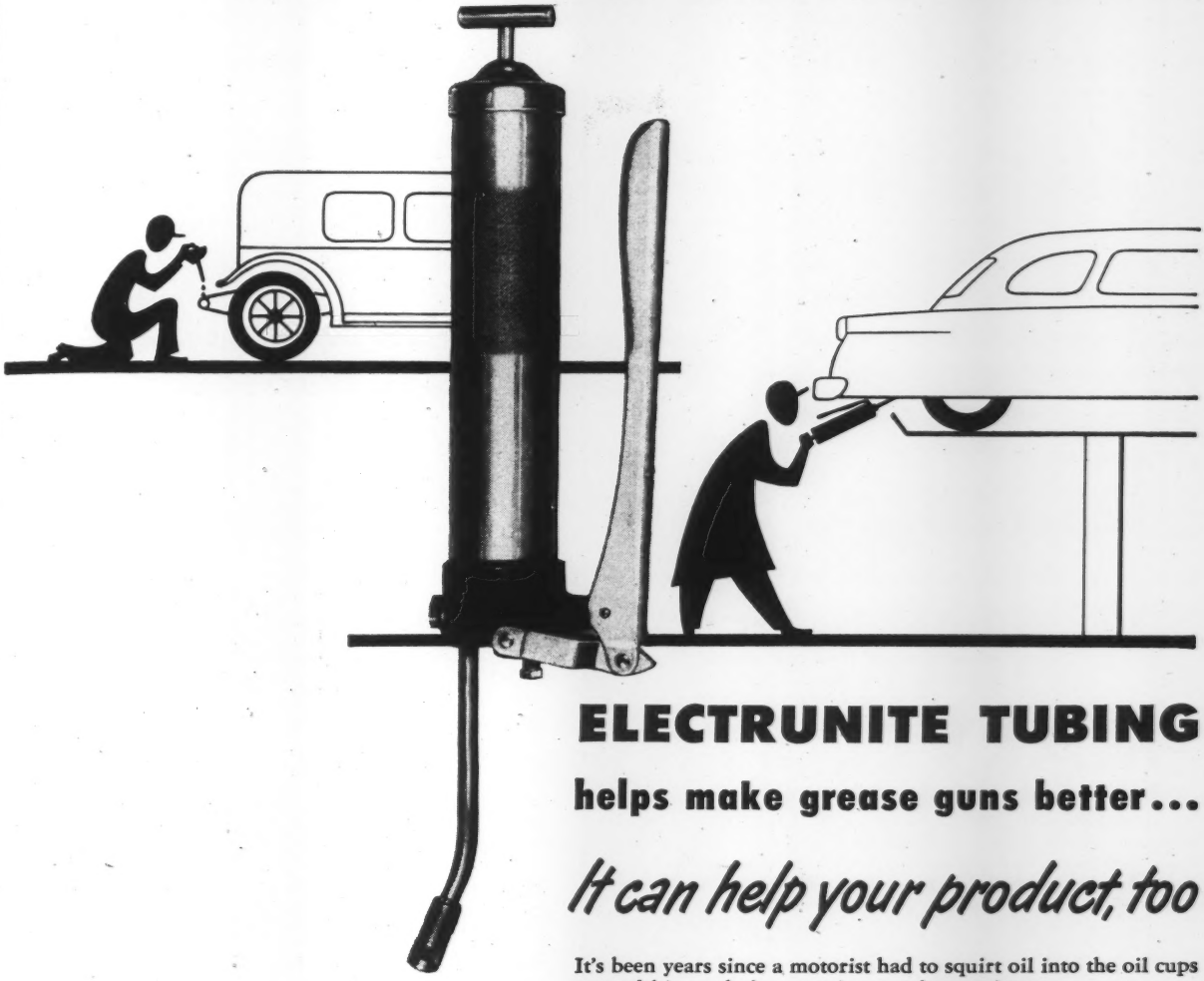
Type C is a floating type control which is capable of transmitting, receiving and correcting at a variable response rate as required. For instance, if the signal indicates a large difference between the required and actual ratio, the corrective brawn unit functions at maximum speed; if the signal indicates a small error, the unit functions slowly. Actually there is in effect a dead band in type C control, since the signal strength is proportional to the unbalance, and until the unbalance has sufficient signal strength to cause the brain unit to operate the brawn unit, the unbalance will continue to exist. If the signal control over the brain unit is supersensitive, the result is a tendency towards excessive hunting.

Program Control

Type D usually is a semiautomatic or full automatic control that establishes a speed versus time relationship through the medium of mechanically driven gearing or cams, commonly called a program control.

In final analysis, if the process and/or drive requirements are capable of actuating a signal, there is a control system available to produce the desired ratio of the variable-speed drive regardless of whether the requirements are di-

another case where welded steel tubing does the job best . . .



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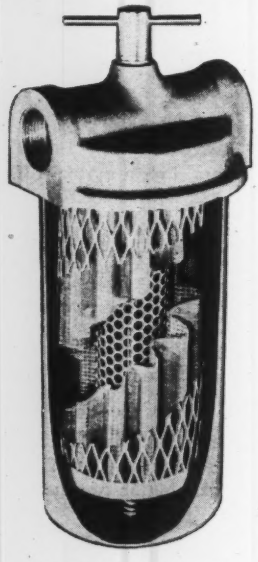
(Photo Courtesy Euclid Road Machinery Co., Cleveland, Ohio)

EUCLID 22 TON MODEL TD FEATURING HYDRAULIC BOOSTER STEERING.

Marvel Synclinal Filters are installed in sump (indicated by arrow) as standard equipment to protect the entire hydraulic system against damage from the highly abrasive particles prevalent under the severe conditions to which "EUCS" are subjected.

MARVEL SYNCLINAL FILTERS

SUMP TYPE (cutaway)



LINE TYPE (cutaway)

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More and more manufacturers and users of hydraulic machines and other equipment with low pressure, non-corrosive liquid systems are depending on Marvel Synclinal Filters to protect their machines efficiency. Marvel Synclinal Filters are speeding production in a wide range of industries. They offer longer periods of operation between cleanings plus simplicity of design which enables ordinary workmen to quickly disassemble, clean and reassemble the filter on the spot. Turning a single handnut releases line type for clecning without disturbing pipe connections.

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Sump and line type models available in capacities from 5 to 100 g.p.m. and in mesh sizes from 30 to 200.

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Specify Oil of Water

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rectly, inversely or variably proportional, provided only that the requirements follow a specific pattern. Each application should be considered from the viewpoint of the required operating performance.

From a paper entitled "Mechanical Variable-Speed Drives" presented at the Twentieth Annual meeting of the ASTE in Chicago, Ill., March, 1952.

Hydraulics or Pneumatics?

By John C. Hanna

Hanna Engineering Works
Chicago, Ill.

AS CAN be substantiated by looking back twenty years, industrial hydraulics and pneumatics today enjoy a greater proportionate use in all machinery. Nearly every division of industry from the most to the least mechanized employs hydraulics and pneumatics in some capacity.

Usually hydraulics and pneumatics do not compete. They are so dissimilar that there are few problems of selection between them which cannot readily be resolved, all factors considered, with a clear preponderance in favor of one or the other. Because only one of the two sources of power is usually at hand, we often see compressed air doing something to which hydraulics might be better adapted, and vice versa. Certainly availability is one of the important factors of selection.

Generally speaking, compressed air is one of the most expensive sources of energy. This is true because, at pressures ordinarily considered, important quantities of heat have been lost in the compression process. Also, apart from the exhaust losses, there are heat and pressure losses during use.

This perhaps leads to wonderment at the tremendous amount of compressed air used throughout industry, particularly in the shop. The answer, of course, lies in the versatility of air, the simplicity of its application, and the fact that in many instances it is not used in really large quantities. One of the

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Here is the bonded-rubber flexible coupling service that you may need . . . the result of analyzing specific coupling requirements.

Lord Shear-Type Flexible Couplings deliver the smoothest power because of the torsional softness of elastic materials stressed in shear. This softness cushions the shocks of starting and stopping . . . it prevents the transfer of shock loads to bearings and gears . . . places natural frequencies beyond operating speed ranges . . . acts as a mechanical fuse to disconnect equipment under overload or stall conditions.

Lord Shear-Type Flexible Couplings are engineered specifically for the work they must do . . . they prolong the service life of driven equipment . . . operate quietly . . . need no lubrication . . . prevent transmittance of noise between shafts . . . cannot be damaged by dust, dirt, abrasives.

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TEXROPE V-Belt Drives with low cost 1800 rpm motors will often do work of expensive motors and control.

For example you can:

1. Provide slow speed (such as 450 rpm) at the driven shaft using a standard 1800 rpm motor. A standard 4 to 1 *Texrope* drive will do it. And the savings over a 450 rpm cage motor, direct connected are:
   - 600 pounds weight (in 15 hp size).
   - About $200 in cost.
   - About 8% increase in efficiency.
2. Use *Vari-Pitch* sheaves on a *Texrope* drive and provide smooth, stepless speed adjustment. There's no need for a high cost special motor or electric control to provide up to 2 to 1 speed range.

For help on your drive problem, whatever it may be, call your nearby Allis-Chalmers distributor or district office, or write Allis-Chalmers, Milwaukee 1, Wis.

A-3734

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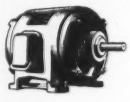

MOTORS — ½ to 25,000 hp and up. All types

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

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advantages of compressed air is its economy as stand-by energy. Once the compressed air has arrived in the line, it stands by at no cost. However, the fact remains that air should be used frugally.

Hydraulics is often discarded as a source of power because one installation requires the design and building of an entire system. Hydraulic power units available on the market are increasing in popularity as a solution to this problem. These units combine several components in a comparatively small package — pump, motors, valves, filters, manifolds, reservoir, controls, etc. However, the initial cost of a hydraulic system is higher than the pneumatic.

Efficiency Considerations

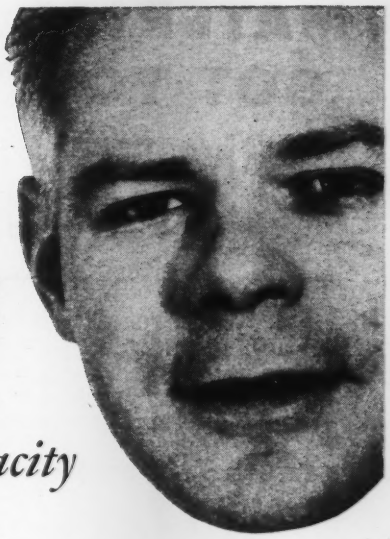
Still other factors must be considered from the cost angle. The efficiency of power transmission in the hydraulic system is superior. Since higher pressures are possible with oil, smaller equipment will be required to meet energy demands. From the maintenance point of view, the oil system is self-lubricating. As a general rule, the design of hydraulic cylinders is such that repacking pistons is unnecessary although in the pneumatic types it is often a must.

Due to the practically incompressible nature of oil, positive displacement with a given fluid volume is possible. Hydraulics provides smoother and more closely controlled movement. Then, there is the important point that higher pressures and thus greater forces are practical with oil.

The characteristics of the fluid, air, mean a comparatively free flow. Also the viscosity of air is not seriously affected by temperature changes. This faster acting medium, once compressed, stores its energy for immediate delivery at any time in large quantity per second.

Engineers often use air where pump hydraulics would be more ideal. The logic is that if air is available in ample quantities the capital outlay for air will be much

if loads are your problem — use **GUIDEROL®** *bearings for greater capacity*



Are you looking for a way to carry greater loads more efficiently in smaller spaces — a way to improve the performance of your tougher bearing applications without increasing bearing space? You'll find the answer in McGill Guiderol Roller Bearings because guided rollers permit full type roller construction without any possibility of roller skewing with limited misalignment. Capacity wasting cages are eliminated and still excessive internal looseness can be avoided. They are available in the MT and CT series — interchangeable respectively with roller bearings of needle type dimensions and ball bearings of single and double row dimensions.

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less than for pump hydraulics. In addition, an air system is often less clumsy, weighs less and is more easily applied. If the engineer will calculate the total amount of air he will use in a year, he will find that the higher cost of air over oil will not amortize the capital outlay for oil over many years.

From a paper entitled, "The Engineer Chooses Pneumatic or Hydraulic Drives," presented at the Twentieth Annual Meeting of the ASTE in Chicago, Ill., March, 1952.

NOISE

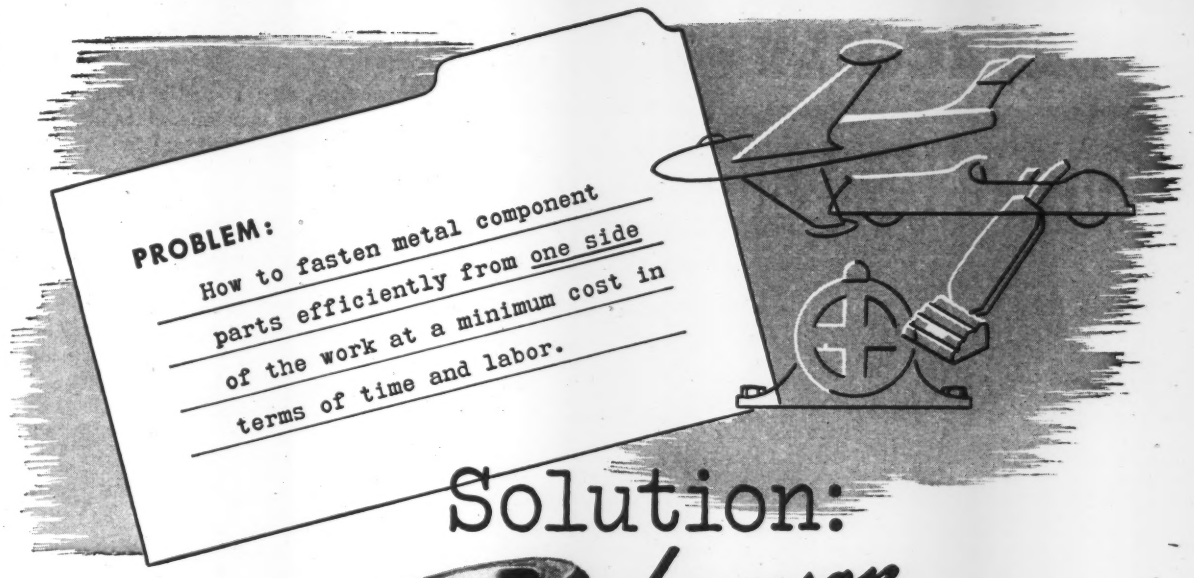
The following three abstracts were taken from papers presented at the Construction Conference of the Cleveland Engineering Society in Cleveland, O., May 1952. Because of their related significance in the study of noise—its effects, measurement and reduction—they are presented as a symposium on this timely topic which is becoming ever increasingly important to the designer.

Sounds in Your Life

By Dr. Richard L. Ruggles

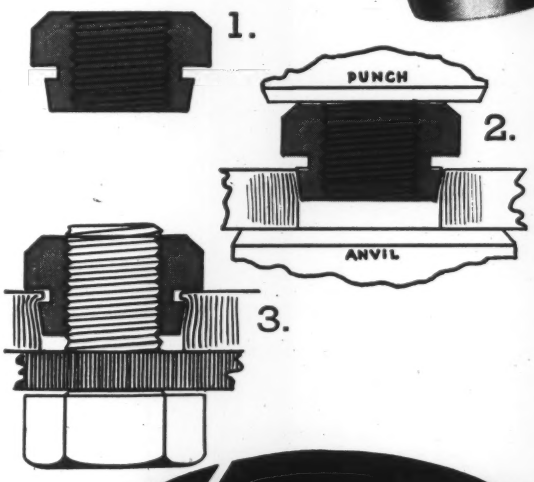
Otolaryngologist
Cleveland, Ohio

TO TEST the functioning of the human hearing system a calibrated audio oscillator known as an audiometer is used to determine the threshold or minimal hearing of the individual, and the results are measured in terms of decibels of hearing loss below that established as normal. Efficiency of the system is greatest in the frequencies between 500 and 4000 cycles falling off above and below these points, as described by the Fletcher-Munson curves. Because of the peculiarity of the nerve supply in the region of 4000 cycles and above, there tends to be a loss of hearing in the 4000 cycle region first, following acoustic trauma. Vowels are heard in the lower range, from 200 to 3000 cycles, and the consonants up to 10,000 cycles, hence the common complaint of a


PROBLEM:
How to fasten metal component parts efficiently from one side of the work at a minimum cost in terms of time and labor.

Solution:

Lamson PLUG NUTS



The Lamson Plug Nut is designed to lick those tough fastening problems where it is difficult or impossible to reach the reverse side of a fastening operation.

Plug Nuts are inserted in the material (as illustrated) to form a threaded "anchor" for a bolt or screw. The bolt or screw can then be seated from the other side to complete the fastening operation.

Designers, engineers and production men will be quick to appreciate the many advantages of Plug Nuts over other types of "one way" fasteners.

Even though they are relatively new, Plug Nuts are already being used with great success on automotive and appliance production lines.

Lamson & Sessions invite design engineers and production men to write for complete information.

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Fasten metal parts efficiently from one side of the work.

PIPE PLUGS
Forged steel, heat-treated.

"1035" SET SCREWS
Cup point type, hardened and heat-treated.

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With "Built-in" spring action for positive locking.

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Economical, vibration proof. Can be used repeatedly.

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REPLACE PIPE COILS
cut costs again

The C. A. Dauer Co., Detroit, Michigan, has found they get more efficient heat transfer at lower cost when they equip their bonderite systems with Platecoils. Use of Platecoils has these five advantages:

Lower first cost.
Simplified and less costly installation.
Takes less space in tank.
Higher heat transfer rate.
No pipe joints in solution.

The 5-Stage Dauer Bonderite Washer pictured above has Platecoils in all five stages. It has electro-polished stainless steel Platecoils in the Bonderite stage and cold rolled steel Platecoils in the other four stages. Because the Platecoils have so much greater prime surface in a given area, smaller size Platecoils can be used. As a result, the initial cost is less, tank capacity is increased and installation is simplified. The Platecoils are easily installed, using simple supports instead of the complicated racks needed for pipe coils. As there are no threaded joints in the solution, the Platecoils are much easier for Dauer's customers to remove for cleaning or repairs. They can be removed and replaced without dumping the solution. Why continue to use costly pipe coils when Platecoils heat or cool so much more efficiently at but a fraction of the cost! Send for bulletin P71 today.

PLATECOILS *for* TANK HEATING *and* COOLING

person with acoustic trauma that he knows someone is talking but he doesn't understand what is being said—he hears "Ah an Ill wen up a hill" rather than, "Jack and Jill went up a hill."

Regarding the pathology there are two main aspects, acoustic fatigue and acoustic trauma. The first occurs in all people and is a temparary effect following exposure to noise. It amounts to about eight or ten decibels of hearing loss at the end of the day, but disappears by the next morning. The effect is also noted in persons with severe hearing losses.

Loss of Hearing

Acoustic trauma is a permanent loss of hearing due to exposure to high noise levels and affects approximately one half of the population. Early in this process there is only ringing in the ears and some loss of the high tones at the end of the day; in particular there is a notching of the audiogram at 4000 cycles as the process continues. Further exposure will cause a greater loss of the high tones as well as some of the low tones. If a person so affected is removed from the noisy areas, he may have a gain of from 15 to 20 per cent as late as 18 months thereafter.

Noise meter readings of 95 decibels or more are generally thought to be capable of producing acoustic trauma; although there is no absolute evidence to establish this figure as the borderline. The frequency of the noise is also thought to be of some importance, in that the high-frequency tones tend to be more harmful than the lower. The octave band analyzer or critical band analyzer is of value in determining the predominant frequencies. Regarding ultrasonics, the only effect produced in man is that of a mild heating of the tissues. Exposing mice to ultrasonics will kill them by overheating, but if the mice are shaved, death will not occur, as shown recently by Air Force studies. There have been a few experiments recently which suggest that there may be some effect upon the balance or-

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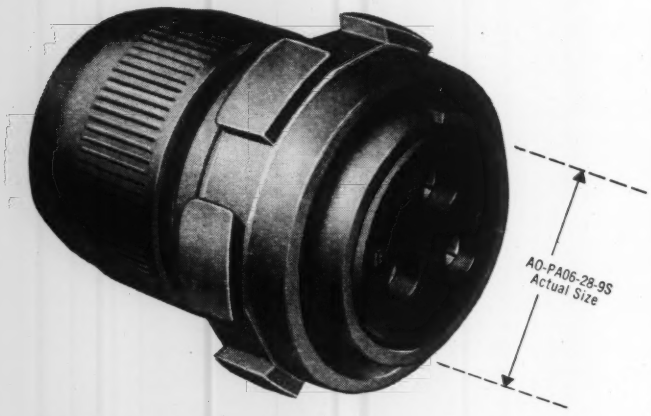

AO Cannon Type AO Series connectors are manufactured under the latest specification pertaining to electrical systems for military vehicles and associated external electrical equipment. "AO" connectors will mate with standard "AN" fittings. Are ideal for heavy duty industrial use.

This new series is designed to withstand extreme conditions of temperature, moisture, dust, vibration and shock. Shell material is aluminum alloy with natural iridite finish. Insulators are of a special molded resilient material having high dielectric strength, medium oil resistance and will not support combustion. Resilient grommet provides moisture proofing over solder terminals.

For engineering data, request Bulletin AO-1952.

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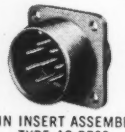
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gan, but not upon hearing.

The duration of exposure to noise is related to the extent of the acoustic trauma, as indicated by the average loss of exposed shipyard workers, who had hearing losses of 30db in one year, 45db in two years and 60db in three years.

Measurement of Noise

By William R. Stern

Brush Development Co.
Cleveland, Ohio

ACOUSTIC measurements in general are more difficult and less precise than the measurements of weight, distance, flow, speed, or voltage. Several factors contribute to this condition: (1) Sound energy cannot be neatly channeled in wires or pipes, (2) ambient noise energy, refracted and reflected sound, introduce problems, (3) hearing varies with the individual, both as to the sensitivity of the ear and the brain's interpretation of the received signal, and (4) the average ear's hearing varies both with intensity and frequency.

It is important that the sound level measuring instrument be similar to the average human ear. However, the ASA realized that it was neither practical nor desirable to exactly duplicate the ear response, and decided that sound level meters should respond according to modified curves for two representative levels, 40db and 70db above 0.0002 microbars. A flat response curve was added for use at very high sound levels or for measuring actual physical sound pressure, and the three weighted frequency characteristics were incorporated into sound level meter designs.

Sound Level Meters: The sound level meter, or as it is often called, the noise meter, is essentially a small portable device for measuring the amplitude of rapid alternations in air pressure. It does not measure the frequency, or pitch, at

When the earliest oxcart creaked and groaned its way in man's most ancient effort at wheel transportation, the driver who shouted the primitive equivalent of "gee" and "haw" had the benefit of power steering. For, he only guided the oxen with his voice or whip—the animals supplied the power for turning.

These days about all we see of the ox is the hamburg in the corner joint, but in taking the animal out of transportation we have loaded part of its work on the drivers of trucks and other vehicles. In trucks without power steering, the driver's muscles have to supply the turning effort. The power must come from his arms, shoulders and back.

Is it progress when we build vehicles that require more physical effort to steer than oxcarts? No wonder drivers tire and become less efficient—lose the fresh alertness that assures safety.

Vickers Hydraulic Power Steering is much better than the ox because you don't have to yell at it or beat it. It takes the work out of steering . . . requires little more effort than a wave of the hand. Wheeling a truck around is so much less tiresome that the driver remains fresh, efficient, safe. For further information, ask for Bulletin M-5100.

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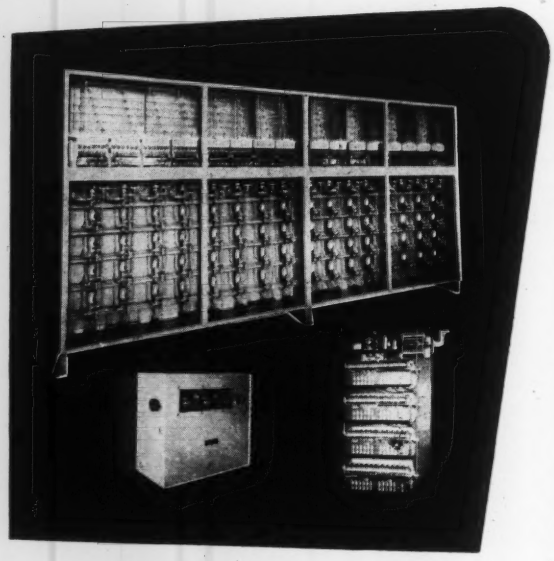

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which such alternations take place. When these alternations occur within a certain range of frequencies they affect the ear and are known as "sound" or "noise". The sound level meter is intended to provide a simple means of obtaining objective measurements which can be correlated with the response of the average ear. However, for many engineering problems the conventionalized response of the sound level meter is more useful than an exact ear response would be since the ear response, by its complicated nature, is not subject to simple mathematical or physical analysis.

The best known makes of sound level meters are more or less alike. They are all intended to follow ASA standards and all leading manufacturers have now adopted similar mechanical and operating features. Noise measuring instruments usually consist of a microphone, an amplifier, a calibrated attenuator, and an indicating meter. In addition, a switch permits the selection of the proper frequency characteristics for the noise level being measured.

Testing Procedures: Proper placement of the microphone is the most important operation in the noise measurement procedure. An infinite number of measurements all around the machine under test would be necessary to accurately measure the total noise output. But in actual practice, measurements are only made at equal intervals around a machine and at a fixed distance from it. Usually, when extreme accuracy is not required, and when the readings are within a range of 10db or so, an arithmetic average of the decibel readings is sufficient.

Selection of the correct weighting curve is important. Sound level ranges and the corresponding recommended weighting curves are:

Sound Level Range	Weighting Curve
24-55 db	*A* (40db)
55-85 db	*B* (70db)
85-140 db	*C* (Equal response over entire range).

At the overlapping levels, for example 55db, a sound may read 54db

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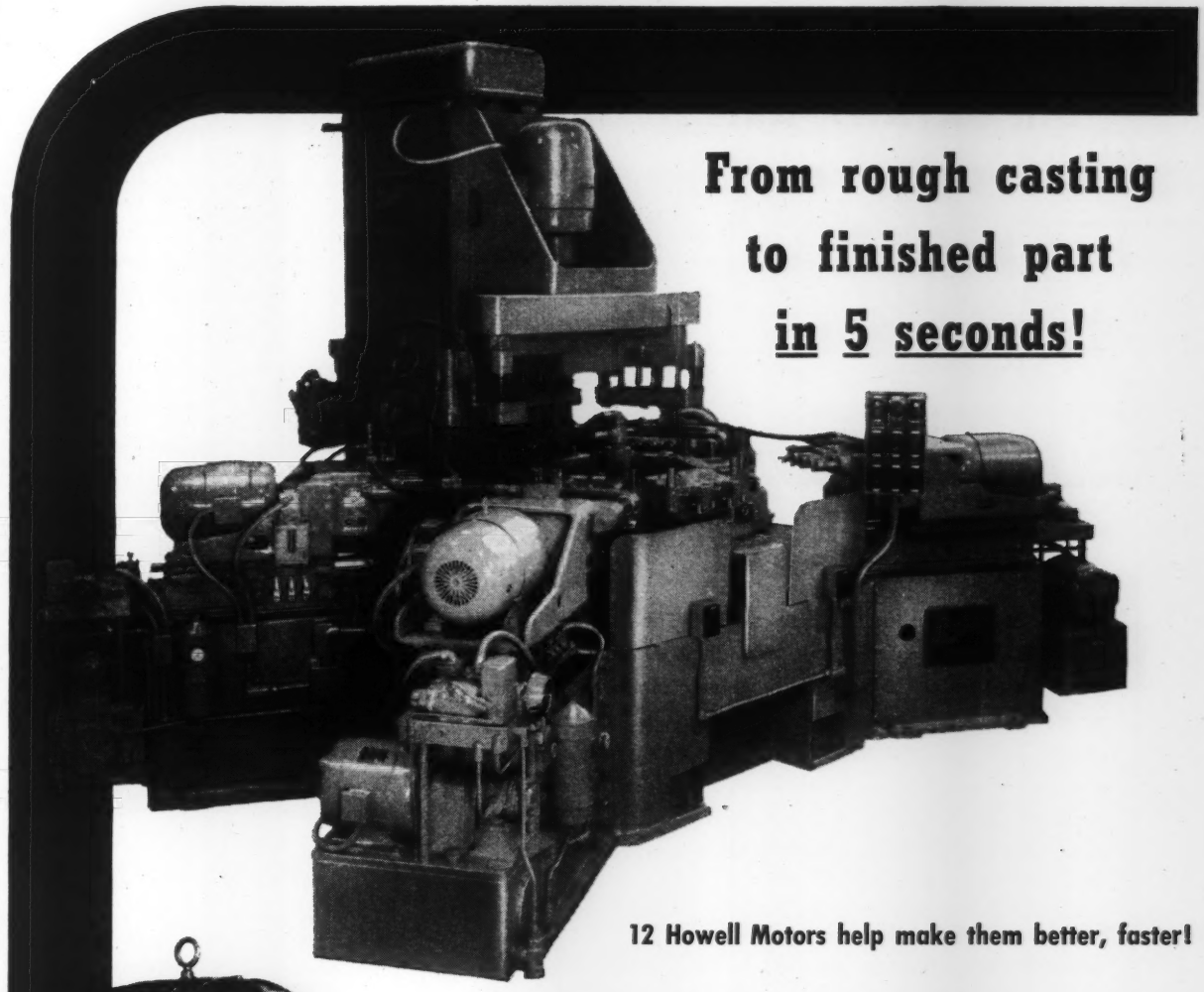

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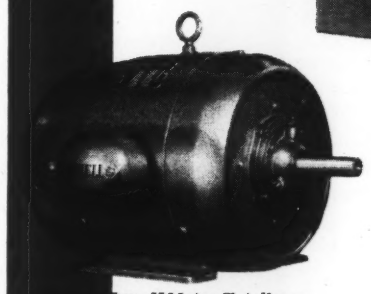
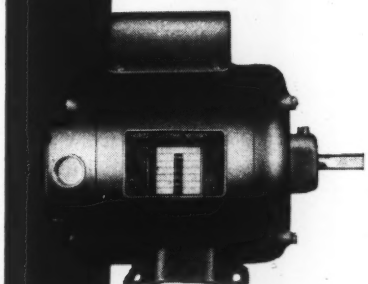


Type K Motor. Totally enfan-cooled. Sizes from 200 H.P. at 1800 RPM.



al horsepower Howell are furnished in standMA frames as either totally enclosed types.

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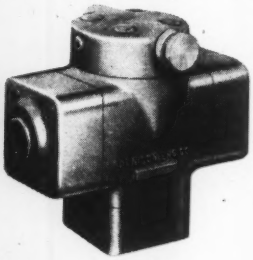
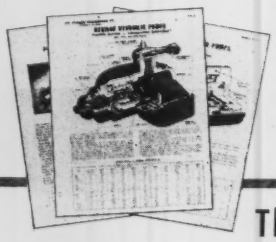


Now . . . *Denison quality* in a bigger-than-ever line of oil-hydraulic pressure controls! HydrOILic Reducing Valves provide independently adjustable pressures for secondary circuits, while main circuit operates at either constant or fluctuating higher pressures. Available in ¾", 1¼" and 1½" sizes, they permit secondary circuit volumes up to 65 gpm. Threaded, flange, or subplate mounting. Write for data.



Get *Denison* quality for all oil-hydraulic circuit needs. Specify HydrOILic Valves, Pumps, Fluid Motors, Pumping Units, Surge-Damping Controls, and the dual-purpose vane-type Pump/Motor featuring *complete radial balance* — for every circuit need. Write today!

The DENISON Engineering Co.

1156 Dublin Road Columbus 16, Ohio

Design Abstracts

on the *A* characteristic and 56db on the *B* characteristic, due to greater weight being given to the lower frequencies on the *B* curve. It is therefore suggested that when making a series of measurements, the setting which covers most of the measurements be used for all the measurements. If the distinction is not clear, it may be necessary to record the measurements with both curves. The weighting curve designation as well as the decibel values should always be recorded.

When studying the annoyance produced at some distance from a noise source, the weighting curve should be used which corresponds to the noise level at the point where the annoyance exists. Measurements close to the annoyance source also should use this same characteristic, since these measurements will be a much better indication of the effectiveness of any quieting procedures. The meter will now be operating with a response more closely duplicating that of the ears of those being annoyed.

Analysis Determines Source

Besides determining the overall noise level, a frequency analysis of the noise will provide many clues to the source of the various components of the noise. Various sound analyzers are available. From a recording of the frequency distribution of the noise, the sources of the sound can be identified through their corresponding frequency components, and definite steps can be taken to reduce noise.

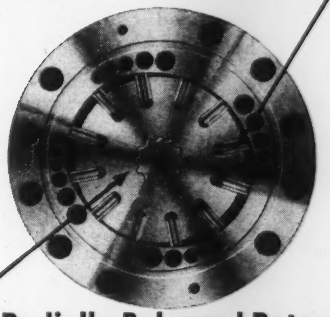
Noise level can be continuously recorded on a chart by connecting the output of a sound level meter to a high-speed level recorder for as long a period of time as desired. For example, the noise level in an industrial plant or at a traffic point may be recorded throughout a 24-hour period or longer to determine the noisiest period and record all maxima. If a detailed picture is needed, a high writing speed is used, recording even the individual hammer blows in a workshop.

A very important need for noise

Today's Biggest Value in a Hydraulic Pump or Motor

New Vane Design gives COMPLETE RADIAL BALANCE

Radially Balanced Vanes reduce vane load on the cam ring *regardless of operating pressures.* When system pressures increase, balanced vanes retain *low* loading characteristics for longer life.



Radially Balanced Rotor.
Opposed inlet and outlet porting provides complete radial hydraulic balance of the rotor.

The pumping cartridge, consisting of cam ring, rotor and vanes, operates with complete radially balanced action — assuring less wear on all moving parts.

A Size for Every Need!

Denison's new vane-type PUMP/MOTOR combines *radial hydraulic balance* with *fully interchangeable pump and fluid motor utility* — to bring you the finest that money can buy in compact power ever offered for 2000 psi continuous duty.

Available in four sizes with a choice of cam rings for each size, the Denison HydrOILic PUMP/MOTOR offers eleven different pumping capacities ranging from 2.7 to 70 gpm.

The same units are also *ready to operate* as fluid motors, without alterations of any kind. They offer 11 different torque capacities ranging from 13 to 257 pound-inches per 100 psi.

Think of the Advantages of These PUMP/MOTOR Features!

Balanced Vane Action. Rugged, specially designed vanes contact the cam ring with dual sealing edges. Complete radial balance assures minimum wear.

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Interchangeable cam rings for each PUMP/MOTOR size widens the range of capacities for both pump and motor applications.

Versatility. Each PUMP/MOTOR is ready for use as either pump or fluid motor *without alterations of any kind* — for continuous duty at 2000 psi.

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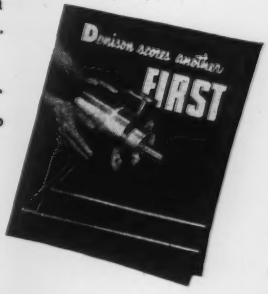

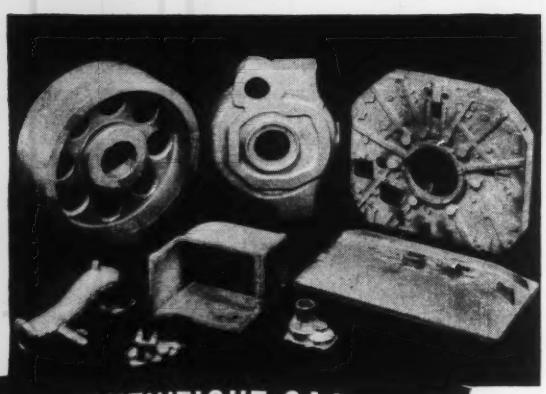

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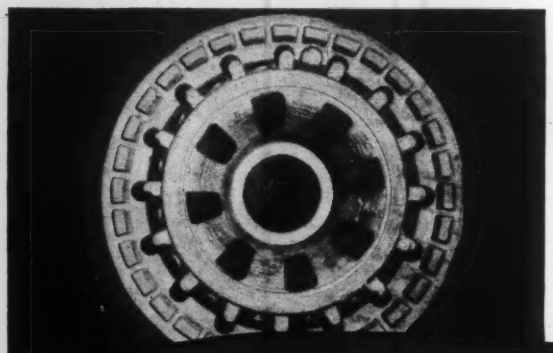

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level recording occurs when the noise to be studied exists only a very short time, too short to be read from an indicating meter; as for example, the noise from passing automobiles, trucks, and aircraft. And of course, the level recorder, when used with a selective amplifier or analyzer, facilitates analysis of the noise spectrogram.

Reducing Noises at Their Source

By R. L. Hansen

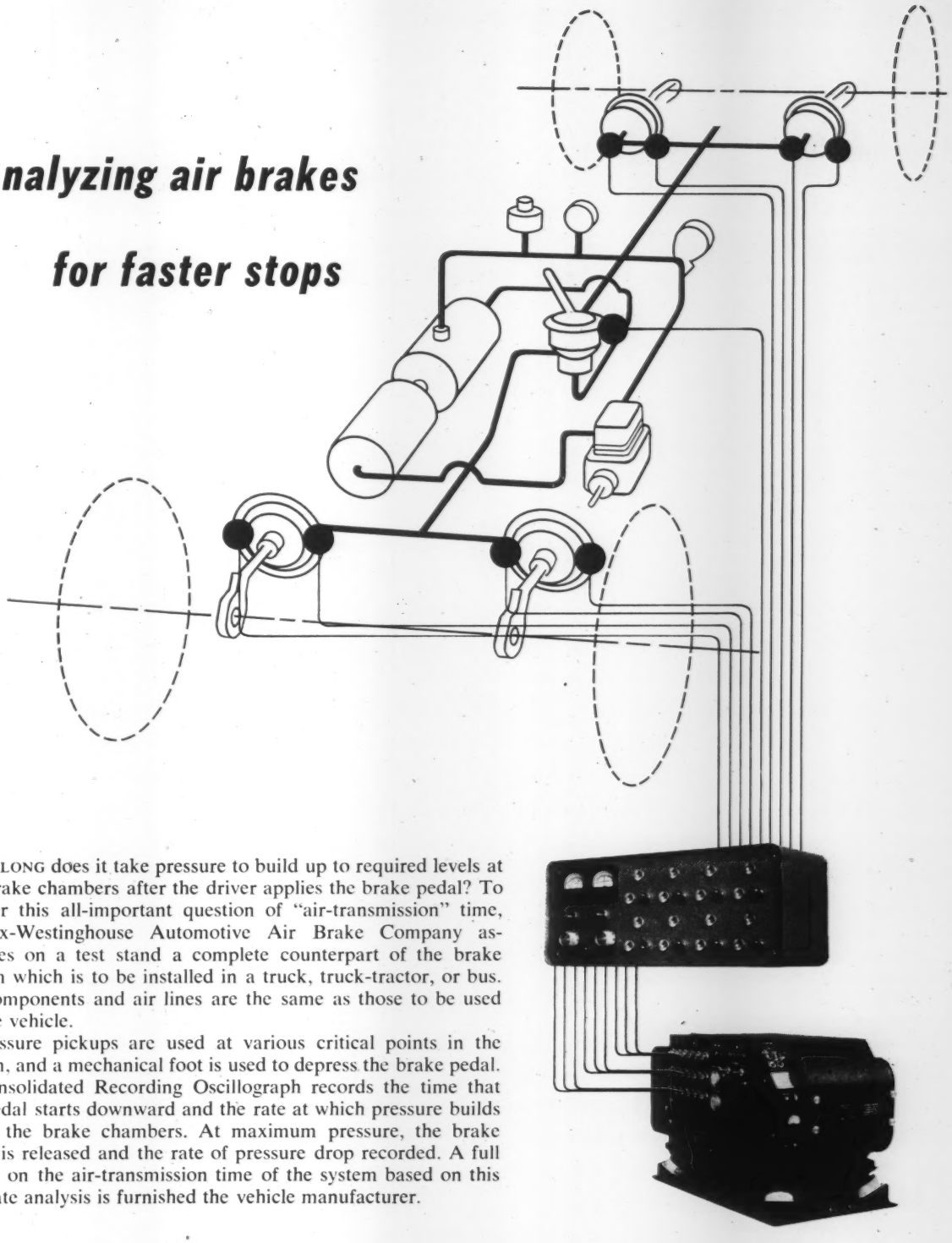
Bell Telephone Laboratories
Murray Hill, N. J.

REDUCTION of noises at their sources should be the first item on any noise reduction program. As in preventive medicine, an operation on the offending source of disturbance frequently accomplishes results which would otherwise be both difficult and costly. Just as a medical doctor must understand the symptoms and causes of disease before he can practice preventive medicine, so must the engineer understand the principles of noise generation and transmission in order to reduce noise.

The intensity of a sound depends on the surface area of the vibrating object, its amplitude of motion, its size, and the frequency of vibration. If a small object such as the shell of a small motor vibrates at a low frequency, for example 120 vibrations per second, very little energy is radiated as sound. However, if the vibrations occur at a much higher rate, say 1200 per second, the greater the amplitude of vibrator motion the greater is the sound intensity.

The coupling between a vibrating member and a resonant object has much to do with the resulting sound. If there is direct mechanical coupling the sound may be very intense, however, when the coupling is made weaker, as through a resilient material such as rubber, the sound is correspondingly decreased. When a vibrating member is required to generate

Analyzing air brakes for faster stops



HOW LONG does it take pressure to build up to required levels at the brake chambers after the driver applies the brake pedal? To answer this all-important question of "air-transmission" time, Bendix-Westinghouse Automotive Air Brake Company assembles on a test stand a complete counterpart of the brake system which is to be installed in a truck, truck-tractor, or bus. All components and air lines are the same as those to be used on the vehicle.

Pressure pickups are used at various critical points in the system, and a mechanical foot is used to depress the brake pedal. A Consolidated Recording Oscillograph records the time that the pedal starts downward and the rate at which pressure builds up at the brake chambers. At maximum pressure, the brake pedal is released and the rate of pressure drop recorded. A full report on the air-transmission time of the system based on this accurate analysis is furnished the vehicle manufacturer.

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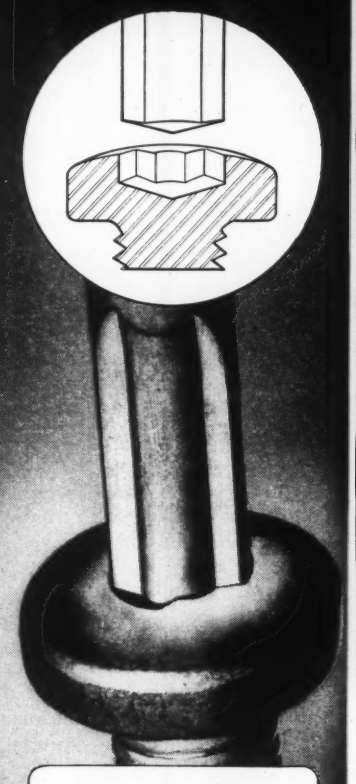
heat through friction as it vibrates at its resonant frequency, the motion decreases more rapidly once the driving force is removed. Also the amplitude is less for the same applied force because a part of the energy is converted into heat. A plain sheet of steel vibrates for some time after being struck by a hammer; but if the same sheet is given a coat of mastic material the vibrations die out rapidly due to the working of the mastic and the resultant dissipation of energy in the form of heat.

Common Noise Generators

The most common noise generators in machines are the rotating parts such as motor rotors, gear trains, etc. and the reciprocating members. Impact noises such as those produced when type strikes the platen of a typewriter or when a follower operates on a cam are common. In ventilating systems, noise is generated by turbulent air from the blades of a fan or from high-speed air passage around corners and obstructions in ducts. In a given machine, any or all of these noise generators may be present and before noise reduction steps can be taken an investigation must be made to determine the offending parts. This is most effectively accomplished by the use of a sound frequency analyzer, an instrument which indicates noise frequencies and their magnitudes. Although after a little experience one can usually recognize simple noises by ear, an analyzer is particularly important in those cases where the noise is complex. Usually, a frequency analysis of machine noise indicates a series of discrete frequencies which can be associated with the moving parts. For example, when gears are involved there will undoubtedly be a frequency component corresponding to the rotational speed of the gear multiplied by the number of teeth. An unbalance in a shaft or pulley may give a noise having a frequency component which matches its rpm. If a fan is involved one may find noise components representing both the blade frequency

UNITED CLUTCH HEAD® SCREWS



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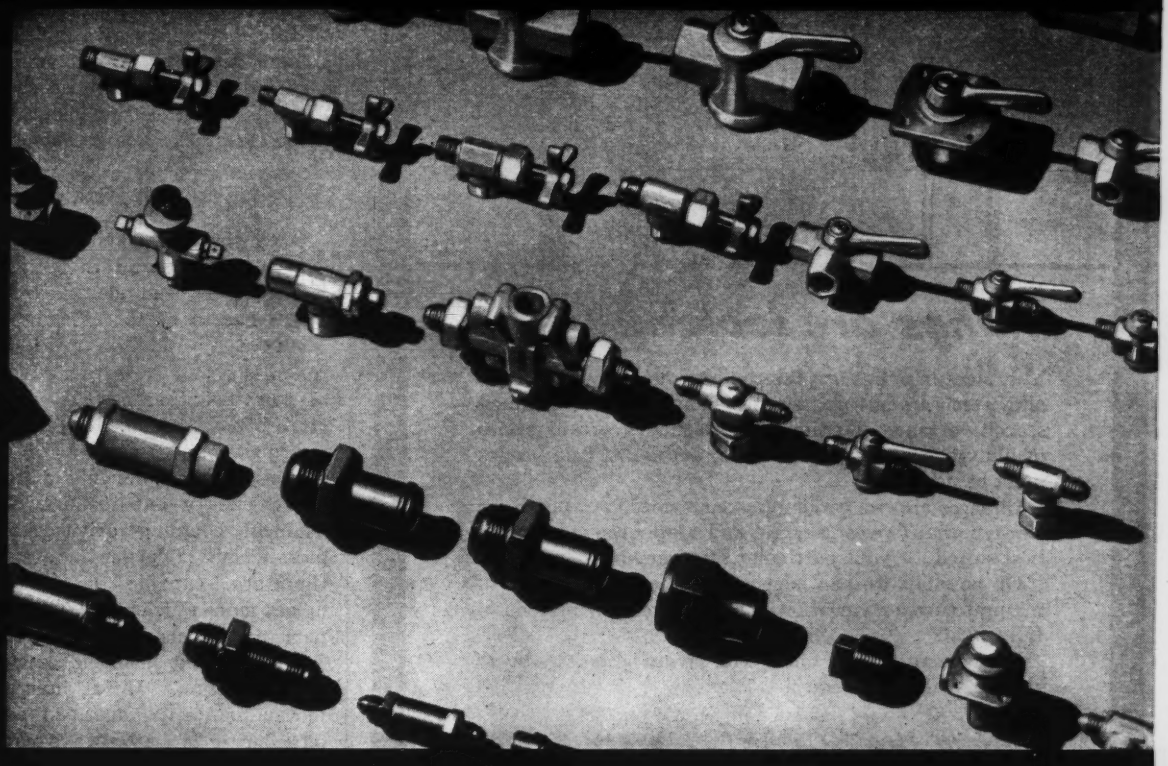

Kohler Co. is a leading supplier of precision controls, including pneumatic, hydraulic, fuel valves and fittings, to manufacturers of jet engines, military, commercial and private aircraft, agricultural and industrial test equipment and Diesel engines.

Facilities for forging, die casting, machining, anodizing, are maintained all in one plant—with an experienced organization skilled in precision workmanship.

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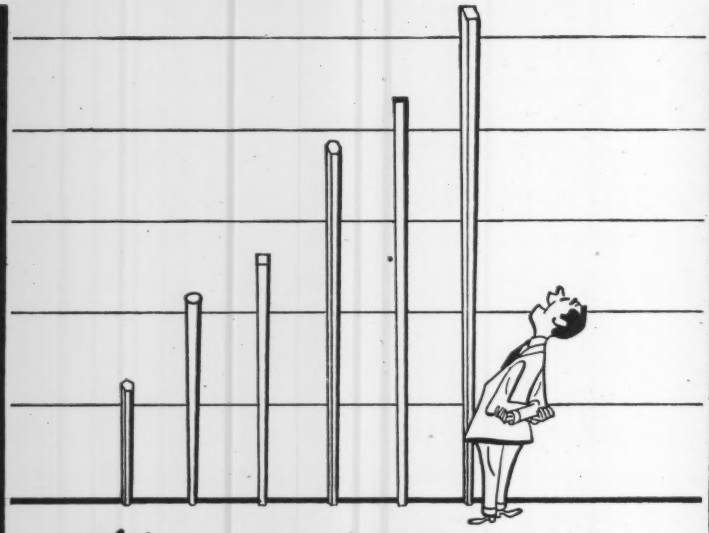

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things are looking up!

Yes, steel supplies *are* improving tonnage-wise! Even alloy steels are in better supply. However, the continued scarcity of many alloying materials makes certain grades of alloy steel still unobtainable, and substitute grades must be used.

Chances are, we can supply your needs . . . but if we can't, perhaps we can suggest and supply the substitutes best suited for your particular requirements.

Or possibly we can suggest alternative methods of manufacture, or variations in your present methods of treatment.

Your nearest W-L office will be delighted to be of service. Call them today!

Get in the SCRAP! . . . every pound means more steel for you!

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

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and shaft speed plus a general noise in which no discrete frequencies are indicated. The exhaust of a combustion engine has a fundamental frequency corresponding to the firing rate plus multiples of the fundamental. An electric motor may give indications of its shaft frequency, commutator bar frequency, and in the case of an ac motor, the fundamental and multiples of the line frequency.

Reducing Noise Radiation

Once the analysis of the noise has been made and the offending causes have been identified it becomes necessary to determine how the noise is radiated to the surroundings and how the efficiency of this radiation can be reduced. More often than not, the origin of the disturbance, such as a noisy motor, does not itself radiate the sound energy but through a mechanical coupling drives another part which is larger in area and therefore capable of radiating noises more efficiently. The driven part may resonate at the driven frequency and hence is easily set into vibration. Even though the motor has been identified as the offender it is not always easy to locate the driven part which radiates the sound. The search can be facilitated by the use of a vibration analyzer, an instrument similar to the sound analyzer except that it indicates mechanical vibration instead of sound pressure. In using the vibration analyzer a probe is placed against the various surfaces and the degree of movement is observed on an indicating meter. After locating the part which is radiating the sound, conditions must be changed so that the sound radiation is less efficient. When possible, the coupling between the motor and the surface should be improved through the use of a more flexible connection. If this is not permissible or not sufficient to reduce the noise to a satisfactory level, the radiating surface should be modified by changing its mass or stiffness or both.

One of the most common causes

WORM GEARING—universal in its application—affords advantages for almost every power transmission job. Whether you want worm gearing sets or speed reducer units, you will find drives to meet your need in the complete Cleveland line. Write for new 180-page Catalog 400, just off press.

Photograph at left of turret punch press, with inset showing built-in Cleveland worm-gearing, by courtesy of Wiedemann Machine Co.

CLEVELAND worm gearing drives turret punch press

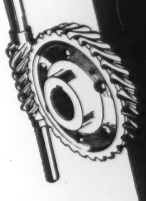
TO insure the smoothness and precision with which any machine tool must operate, there is an ideal drive—Cleveland Worm Gearing.

Worm gearing as built by Cleveland is rugged, efficient and dependable. It transmits power with a smooth, quiet, steady torque flow. It is compact and space saving. And speed reduction to any desired ratio is possible.

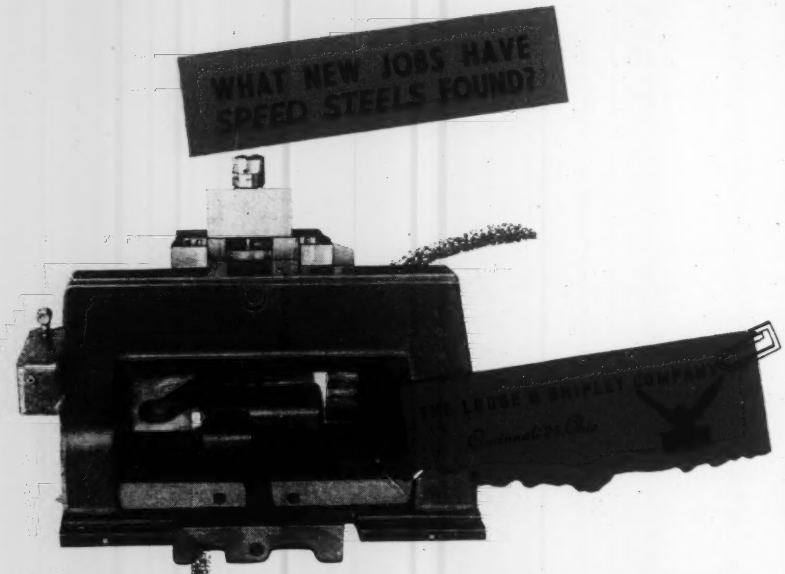
For 40 years Cleveland has devoted its facilities exclusively to engineering and manufacturing highest quality worms and gears. No wonder that so many Clevelands installed in the teens and twenties are still in service.

If you are building or using equipment that calls for worm gearing, of either standard or special sizes and types, just drop us a line. The Cleveland Worm and Gear Company, 3265 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.



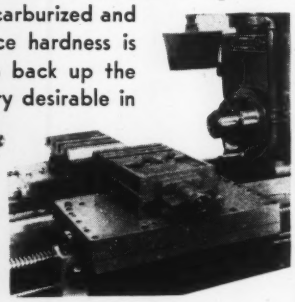
CLEVELAND
Speed Reducers



"SPEED ALLOY STEEL PLATE WELL SUITED FOR CAMS"

—That's the opinion of Lodge & Shipley Co., Cincinnati, Ohio, who are successfully using Speed Alloy hot rolled alloy steel plate for the cam plate of the cam-operated rear cross slide on their famous "2A Duomatic" Lathe. They state:

"Speed Alloy was selected for the cam plate because it is particularly suited for cams. A considerable saving in machining time has been found over other suitable steels. Definite figures are unavailable, but the savings are probably in the order of 10%. The cam slot is carburized and heat treated to 50-55 Rockwell C. This surface hardness is readily attainable, with good core hardness to back up the case. Reduced distortion of Speed Alloy is very desirable in this part . . . distortion from heat treating has been no problem."



Speed Alloy has cut costs for many producers of molds and zinc die casting dies and on a variety of machine parts. Maybe it's the answer to your problem. Check with your Speed Steels Distributor.

SPEED STEELS

SPEED ALLOY ■ SPEED CASE ■ SPEED TREAT

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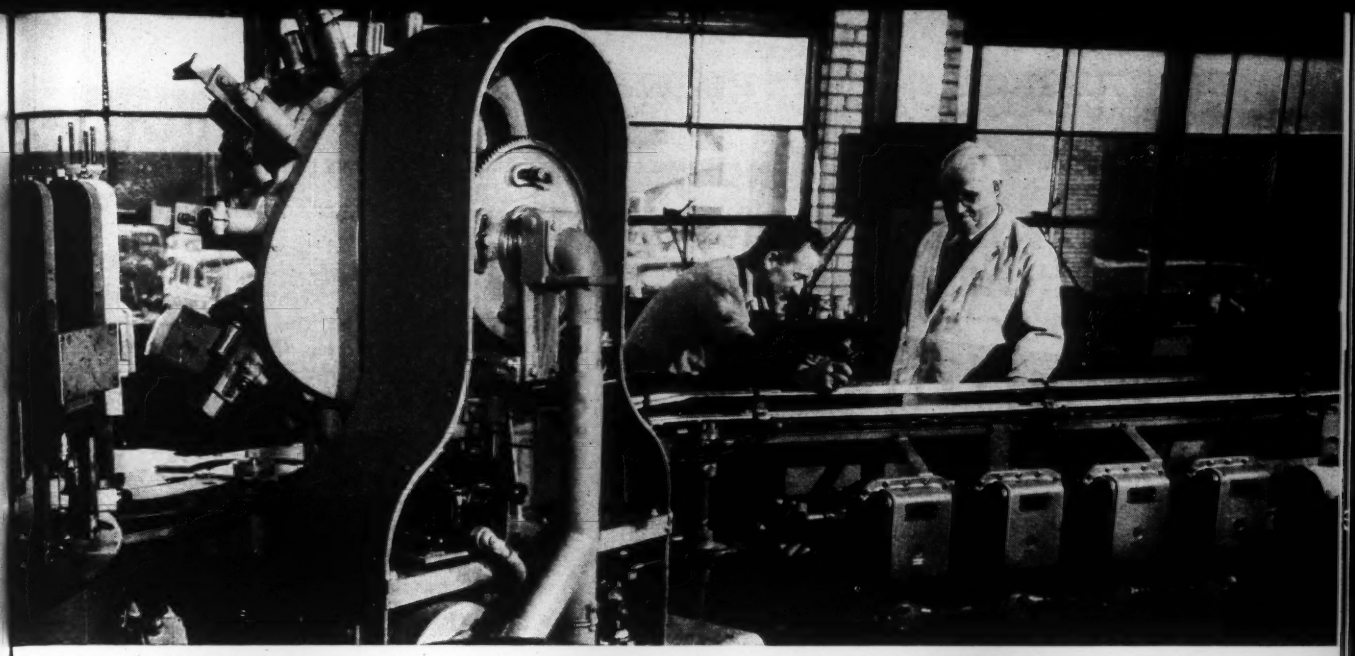
Produced by W. J. Holliday & Co., Inc., Speed Steel Plate Division, Hammond, Indiana. Plants: Hammond and Indianapolis, Indiana

of noise is too rigid a mount between a machine and supporting structure. In this case vibration is transmitted to a floor or wall and then to the various parts of a building where it is radiated. This type of installation calls for isolation of the machine through resilient mountings such as rubber, cork, felt or one of the many commercial types of mountings designed for the purpose. The mounting should be so chosen that the natural frequency of vibration of the machine on the mounting is well below the lowest frequency of vibration which is to be suppressed. For example, if the lowest frequency of the machine is 30 cycles, the resonant frequency of machine and mount should not be higher than 10 cycles; the lower this value, the more effective will be the isolation. When the mass of a machine is so low that it is difficult to satisfy this requirement, more mass can be added to the machine. Common practice is to mount the machine rigidly to a massive concrete block with a resilient mounting under the block for isolation.

Utilizing Housings

When a practical noise reduction has been reached by operations on the sources, further improvement may be obtained by enclosing the noisy machine in a housing. In most cases satisfactory housings can be made from relatively light-weight material, for example, 1/16-inch aluminum sheet. However, precautions must be taken to stiffen the walls by bracing or by pressing corrugations into the material. The interior surfaces should be coated with a mastic material, such as that commonly used on the inside of the panels of car bodies, and lined with an efficient sound absorbing material such as rock wool, fiber glass or felt. If openings are required for ventilation purposes circuitous lined ducts should be used. In mounting the housing on the machine, care should be taken to prevent any direct mechanical coupling between the two.



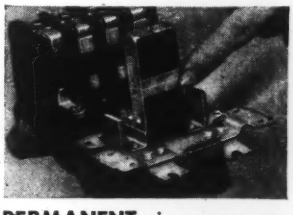
PNEUMATIC SCALE CORP., LTD. makes complex bottling and packaging machinery. They report that G-E magnetic starters give reliable service, fool-proof motor protection. Above, one of Pneumatic's "bottling lines" is being assembled. It cleans, fills, caps and labels in one continuous, automatic operation—uses full-voltage General Electric magnetic starters to protect its many motors.

These Leading Companies Say: "G-E Starters Last Longer!"

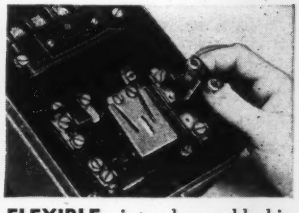
Like many other leading companies throughout industry, the Pneumatic Scale Corp., Ltd., Quincy, Mass., and The Van Dorn Iron Works, Cleveland, Ohio, report that G-E magnetic motor starters give *longer-lasting* protection! This extra long life is due to many exclusive G-E features, such as the permanent air gap, illustrated below, and the famous G-E "Strongbox" coil.

G.E.'s wide variety of ratings, enclosures and interchangeable components will meet any starting requirements

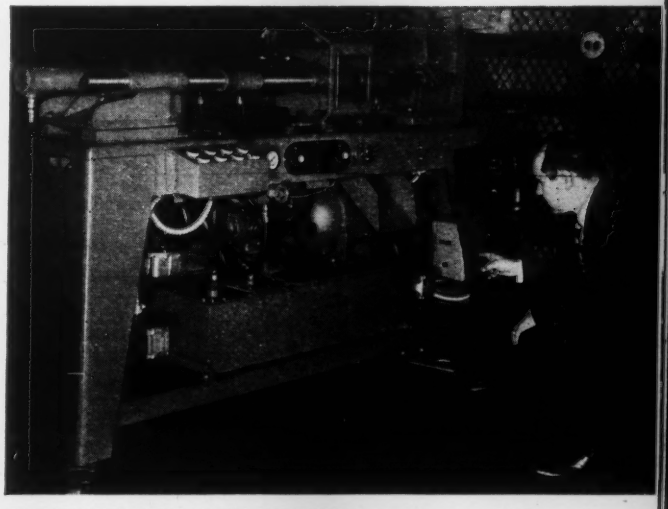
You can get G-E starters, right now, from your nearest G-E Apparatus Sales Office or authorized distributor. For more information on G-E starters and control accessories, write for bulletin GEA-5781, to *Section A730-37A, General Electric Co., Schenectady 5, N. Y.*



PERMANENT air gap assures against failure even after millions of operations.



FLEXIBLE: interchangeable bimetallic overload relays match starter to motor.



THE VAN DORN IRON WORKS' Sales Manager J. J. Reichel, pointing to Van Dorn plastic moulding machine, says, "G-E magnetic starters are the best long-term assurance we can give our customers against motor burn-outs. We've used these starters on over 1000 machines and never a complaint on electrical equipment!"

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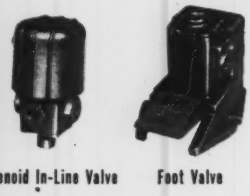
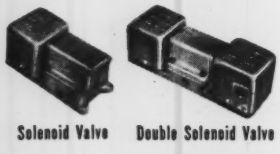
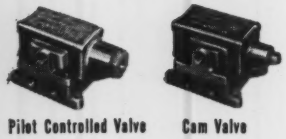


Solenoid In-Line Valve | Foot Valve

Solenoid Pilot Valve | Hand Valve



Solenoid Valve | Double Solenoid Valve



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Straightway, 3 way, 4 way

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Sizes: ¼" thru ¾"

EFFICIENT! Full flow design . . . plus simplified construction with only one moving part . . . add up to more dependable performance, longer life, reduced maintenance.

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Meetings

AND EXPOSITIONS

Aug. 11-13—

Society of Automotive Engineers. West coast meeting to be held at the Fairmont Hotel, San Francisco, Calif. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary.

Sept. 4-5—

National Conference on Industrial Hydraulics. Eighth annual meeting to be held at the Sherman Hotel, Chicago, Ill. J. G. Duba, Illinois Institute of Technology Technology Center, Chicago 16, Ill., is secretary.

Sept. 8-10—

American Standards Association. Third National Standardization Conference will be held in conjunction with the Centennial of Engineering at the Museum of Science and Industry, Chicago, Ill. Additional information may be obtained from society headquarters, 70 East 45th St., New York 17, N. Y.

Sept. 8-11—

American Society of Mechanical Engineers. Fall meeting to be held at the Sheraton Hotel, Chicago, Ill. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Sept. 8-12—

Instrument Society of America. Annual fall meeting and exhibit to be held at the Public Auditorium and Hotel Cleveland, Cleveland, O. Richard Rimbach, 921 Ridge Ave., Pittsburgh 12, Pa., is secretary.

Sept. 8-12—

American Society of Mechanical Engineers. Industrial Instruments and Regulators Division, joint conference with Instrument Society of America to be held at the Cleveland Auditorium, Cleveland, Ohio. C. E. Davies, 29 West 39th St., New York 18, N. Y., is secretary.

Sept. 9-11—

Society of Automotive Engineers. National tractor meeting to be held at Hotel Schroeder, Milwaukee, Wis. John A. C. Warner,

Lassman HEAVY DUTY Cylinders are Custom-Made to Meet Your Particular Requirements

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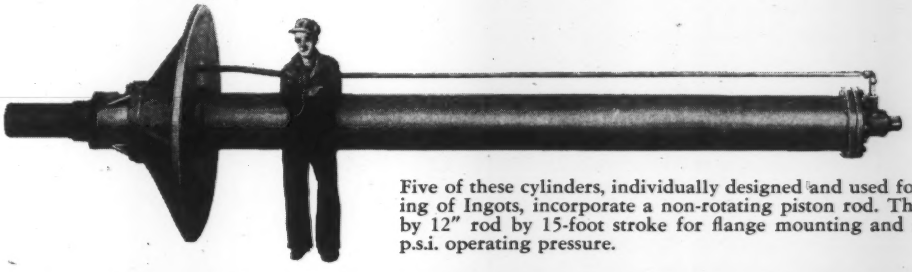

Five of these cylinders, individually designed and used for Continuous Casting of Ingots, incorporate a non-rotating piston rod. They are 14¼" bore by 12" rod by 15-foot stroke for flange mounting and are built for 2000 p.s.i. operating pressure.

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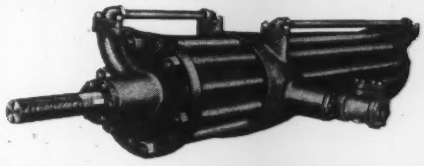
It provides hydraulically powered straight line motion in a compact, self-contained unit. It comes complete, ready for mounting in place and wiring up and is available in various load ratings and speeds.

HEAVY DUTY HYDRAULIC CYLINDER



Another individually designed Cylinder, made for Steel Coil Up-Ender. 10½" bore x 3" alloy steel rod x 68" stroke 3,000 p.s.i. with 1¼" hydraulically balanced swivel pipe connections.

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Meetings and Expositions

29 West 39th St., New York 18, N. Y., is secretary.

Sept. 11-14—

Packaging Machinery Manufacturers Institute, 20th annual meeting to be held at the Homestead, Hot Spring, Va. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

Sept. 29-Oct. 1—

National Electronics Conference. Eighth annual conference to be held at the Sherman Hotel, Chicago, Ill. under the sponsorship of the American Institute of Electrical Engineers, the Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and the University of Illinois, with participation by Purdue University, University of Wisconsin and the Society of Motion Picture & Television Engineers. Additional information may be obtained from S. R. Collis, Chairman, N.E.C. Publicity Committee, 208 West Washington St., Chicago, Ill.

Oct. 10—

National Noise Abatement Symposium. Third annual symposium to be held at the Armour Research Foundation of Illinois Institute of Technology. Daniel B. Callaway, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., is chairman.

Oct. 29-31—

American Society of Body Engineers. Seventh annual technical convention to be held at the Rackham Memorial Bldg., Detroit, Mich. Additional information may be obtained from society headquarters, 100 Farnsworth Ave., Detroit 2, Mich.

Oct. 30-31—

ASME Fuels and AIME Coal Division Joint Conference to be held at the Bellevue-Stratford Hotel, Philadelphia, Pa. Additional information may be obtained from C. E. Davies, 29 West 39th St., New York, N. Y.

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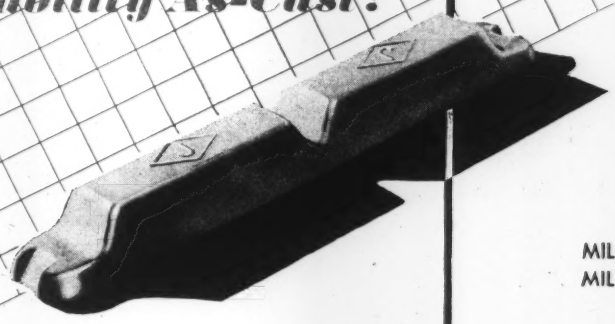

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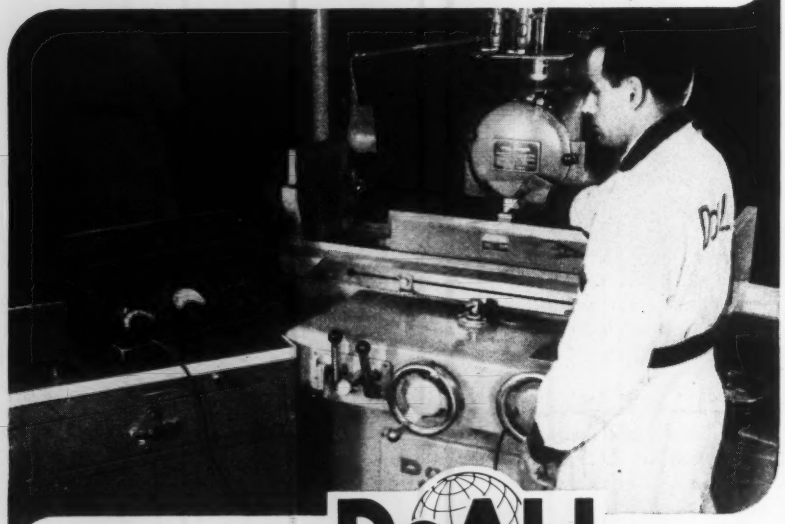

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The DoALL Company of Des Plaines, Illinois, world famous manufacturer of machine tools, gages and cutting tools, gives customers an exclusive analysis of the precision and dependability of each DoALL Precision Surface Grinder.

To do this, DoALL relies on the Profilometer as the final check made on every grinder manufactured.

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Freezer: Model NA-8J has 8-cu ft capacity. Inner liner is aluminum rather than porcelain-enameled steel. Features temperature indicating light, counterbalancing hinges, automatic interior light and exterior finish of two coats of white, baked enamel. Refrigerant coils are brazed directly to liner walls to speed freezing. Both lid and cabinet are insulated with a new type of Fiberglas thermal insulation to assure a uniform low temperature throughout storage area of cabinet. Cabinet is divided into upper and lower sections. Three removable baskets comprising upper section slide on angle supports to provide access to lower section. Total interior depth is 18 in. Sealed-in refrigerating system is located directly below freezing cabinet. *Major Appliance Div., General Electric Co., Louisville, Ky.*

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QUALITY, PRODUCTION-engineered EATON Springtites and Sems (bolts or thread-cutting screws with pre-assembled Reliance spring lock washers or multitooth washers) cut assembly motions for hundreds of users. In fact, in actual use, they cut these assembly motions from 8 to 3! Here's real economy on your assembly line operations. All the engineering data and samples you require for a trial test can be obtained by writing us today.

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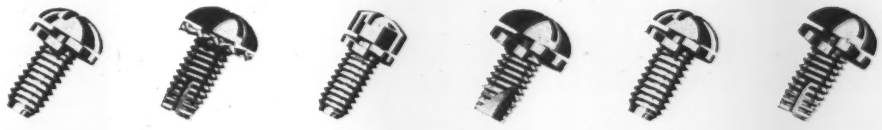

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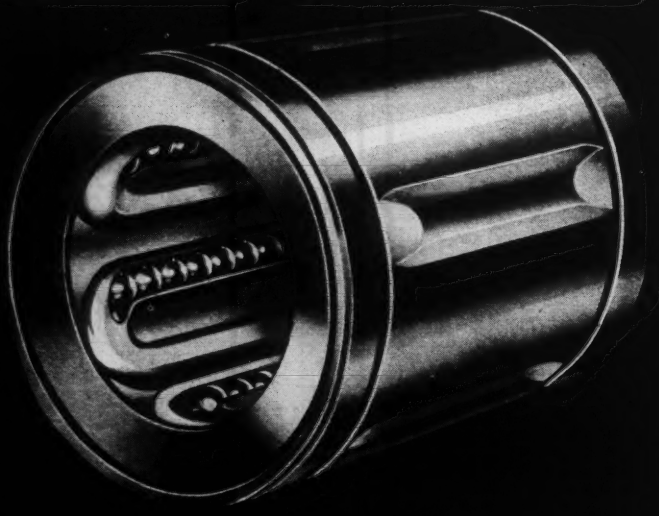
BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for 1/4", 1/2", 3/4", 1", 1 1/2" and 2 1/2" shaft diameters.

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ELIMINATES BINDING AND CHATTER
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Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

nonsparking units also available for handling volatile liquids. *Kist Machine Co. Inc., Buffalo, N. Y.*

Metalworking

Work Feeder: Two-station electrically-controlled, air - powered unit designed to cut idle machine time in half. Has a movable table top 11/16-in. thick by 5¼ in. wide by 12 in. long guided on hardened and ground dovetail ways. Power for transverse motion of table is supplied by Bellows BEM 5-60 air motor with built-in Electroaire valve. Has 6-in. transverse stroke, which allows operator to load and unload work at one end of table while machining is underway at the other end. Equipped with adjustable positive stops for accurate work positioning to eliminate manual error and resulting spoilage loss. *The Bellows Co., Akron, O.*

Deep Hole Drilling Unit: Uses step-by-step feeding principle. Can be installed on most drill presses; is mounted above the spindle to conserve aisle space. Unit begins cycle with rapid approach and stops about 1/32-in. above work. Drill is then fed into work at infinitely variable speeds and in steps ranging in depth from 1/32 to ⅝ in. Drill is automatically and rapidly retracted from work to remove chips from hole. At this stage, coolant enters partially drilled hole. Cycle is repeated until predetermined depth of hole has been reached, then drill withdraws from hole and machine shuts off automatically. May also be used as conventional drill feed unit through a simple changeover adjustment, or may be manually operated. *The General Pacific Corp., Los Angeles, Calif.; The General Detroit Corp., Detroit, Mich.*

Engine-Driven Welder: Equipped with complete engine accessories and auxiliary apparatus; can also supply 110-v, 60-cycle, single-phase power. Nominal rating of welder is 200 amps, 40 v, 60 per cent duty cycle with current range from 40 to 250 amps. Welding current is controlled in four ranges by a tap switch and shunt field rheostat. The ac power circuit includes con-

Savings up to 42% on fuel oil and lube oil

Fairbanks-Morse does it with dual-fuel engines

...all Ross Exchanger equipped!

"Put your power costs in order with Fairbanks-Morse dual-fuel engines." That F-M statement is based on facts like these:

In Minnesota, fuel costs cut 42 per cent. In a Kansas power plant, savings of $19,000 a year in fuel and lube oil. In Arkansas, overall savings of $33,000 annually!

To achieve such economies, many of the engines are in 'round-the-clock operation. Naturally, that means all components must give the same unfailing performance. Take the Ross Exchangers for example. They are and *can be* depended on to keep lube oil and jacket water at proper temperature levels. Downtime or lowered performance through overheating can't be risked.

That's why, on Fairbanks-Morse installations, such as the ones shown, you so frequently find Ross Exchangers among the principal equipment. Fairbanks-Morse must safeguard its own in-built quality with components of equally known dependability.

For Diesel, gas or dual-fuel engines of any rating, pre-engineered Ross Exchangers have unequaled advantages: standardization that simplifies engineering, diversification of standard sizes to cover most requirements, and choice of materials for specific conditions.

Details of construction, engineering data and collaboration on your specific needs gladly furnished. Bulletin 2.1K1 mailed on request.

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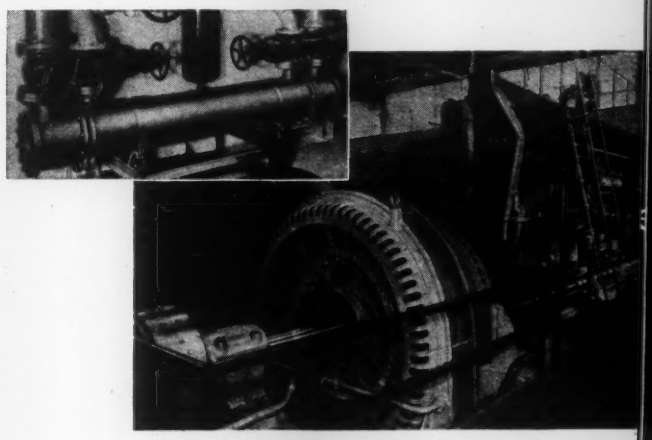
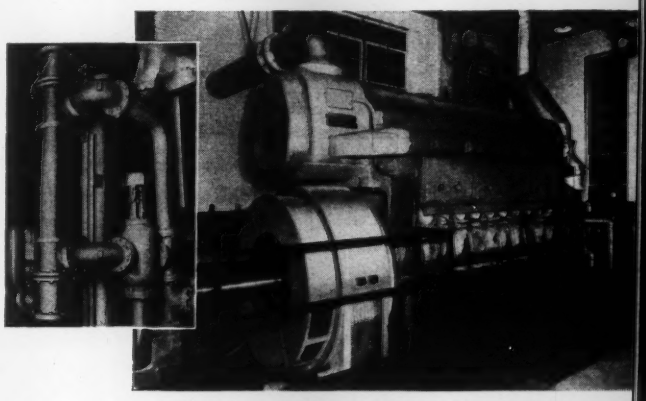
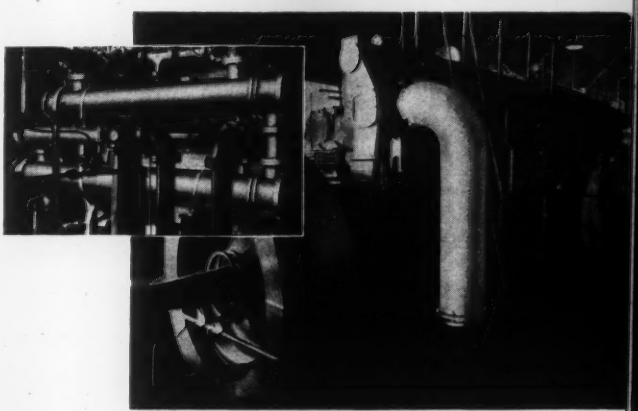


Fairbanks-Morse 1400-hp dual-fuel engine equipped with Ross Exchanger for lube oil cooling.



Fairbanks-Morse 1600-hp opposed-piston Diesel equipped with two Ross Exchangers: one for jacket water, the other for lube oil



Fairbanks-Morse 2000-hp dual-fuel engine equipped with two Ross Exchangers for lube oil and jacket water cooling.

ROSS EXCHANGERS

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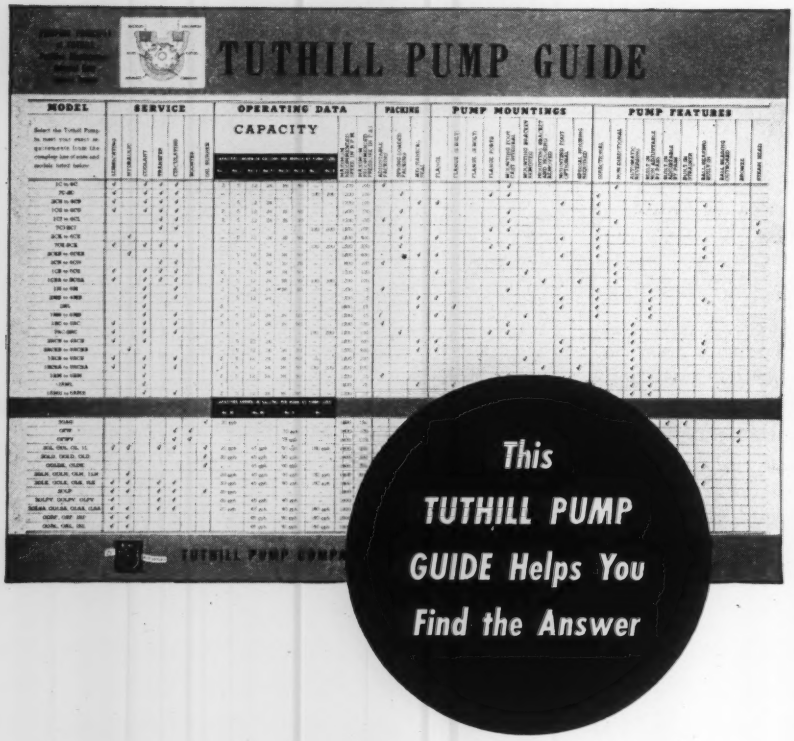
NEW EASY WAY TO SELECT THE RIGHT PUMP FOR THE JOB



To save you time and trouble in selecting the pump best-suited to your application, Tuthill engineers have developed this revolutionary new Pump Guide. Here, in one easy-to-use chart, is a volume-full of information on the complete line of Tuthill Pumps.

At a glance, it shows you the services for which each model is built, together with performance characteristics, types of packing, mounting styles and distinctive features that enable you to fit the pump to your need, rather than the need to the pump.

Copies of this helpful guide are now available on request. Write for yours today—there's no obligation.

Tuthill Positive Displacement Pumps serve Industry in Lubrication, Hydraulic, Coolant, Oil Burning, Circulating and Transfer Service.

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ventional plug-in outlets, a voltmeter, and a breaker for overload protection. Especially adapted to field welding in construction and maintenance operations. Designed for truck transport as a unit or for mounting on a trailer equipped with pneumatic-tired wheels. Size: 39½ in. high from base surface to top of lifting eye; overall length, 62⅝ in. *Westinghouse Electric Corp., Pittsburgh, Pa.*

Spring Coiler: Hand-operated machine for making compression, extension and torsion springs. For making experimental and small production lots of springs up to approximately 1000 pieces per run. Compression springs are coiled with both ends squared automatically. Extension and torsion springs can be wound either left or right-hand with long extended arms on both ends. Capacity: wire diameters from 0.004 to 0.063-in., with outside diameters up to 1 in. and spring lengths up to 4 in. *The Carlson Co., New York, N. Y.*

Hydraulic Drive: Attachment for powering ram type hand turret lathes. Also adaptable to powered ram turrets. Designed for six-station turret lathes; adaptable to lathes with bar stock capacity up to 2½ in. Consists of ¾-hp motor, two pumps, reservoir, fluid motor, control valves and connections. Pumps, motor and reservoir fit under end of machine; fluid motor attaches to turret pilot wheel shaft. Control body mounts on end of turret. Automatic individual cycles and feed rates can be set to suit different operations in six or fewer number of turret positions. Circuit control rods and adjustable dogs provide means for controlling rate and length of feed. Cycles for each of the six positions can be set for rapid approach, dwell, infinite adjustable feed and quick return. *Viking Industries, Rockford, Ill.*

Automatic Screw Machine: Model No. 4 for production of medium-sized parts requiring close tolerances and good finish. Spindle has positive chain drive with 168 two-speed combinations changed by simple pick-off gears. Wide range of high to low speed ratios makes

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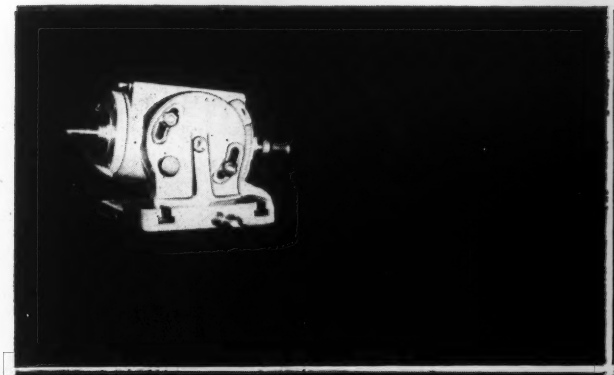

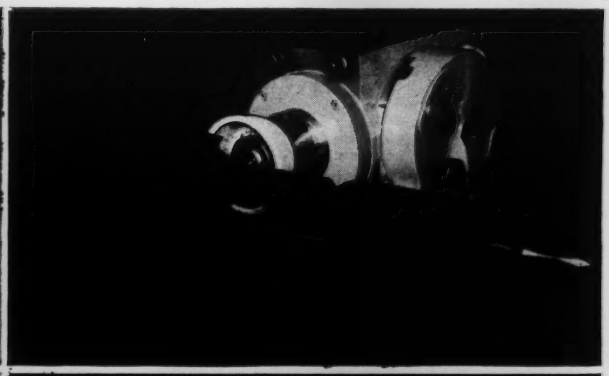

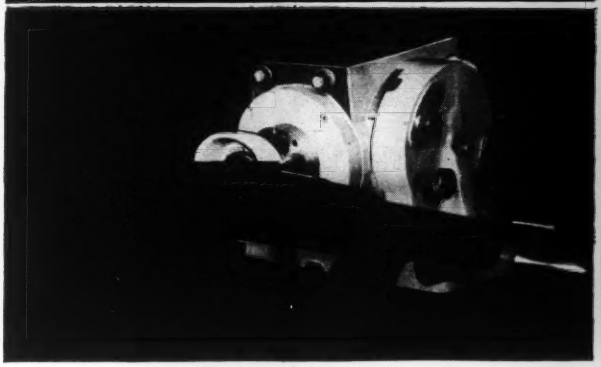

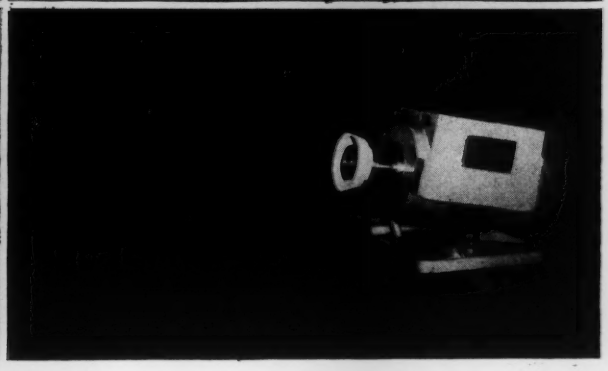

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Specify this new and better motorized Spindle on your next tool and cutter grinder.

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This totally enclosed POPE Spindle with sealed-in lubrication has the radial and axial rigidity to make wheels cut faster — spark out quicker.

It produces the kind of cutting edge on your tools that stands up and cuts longer.

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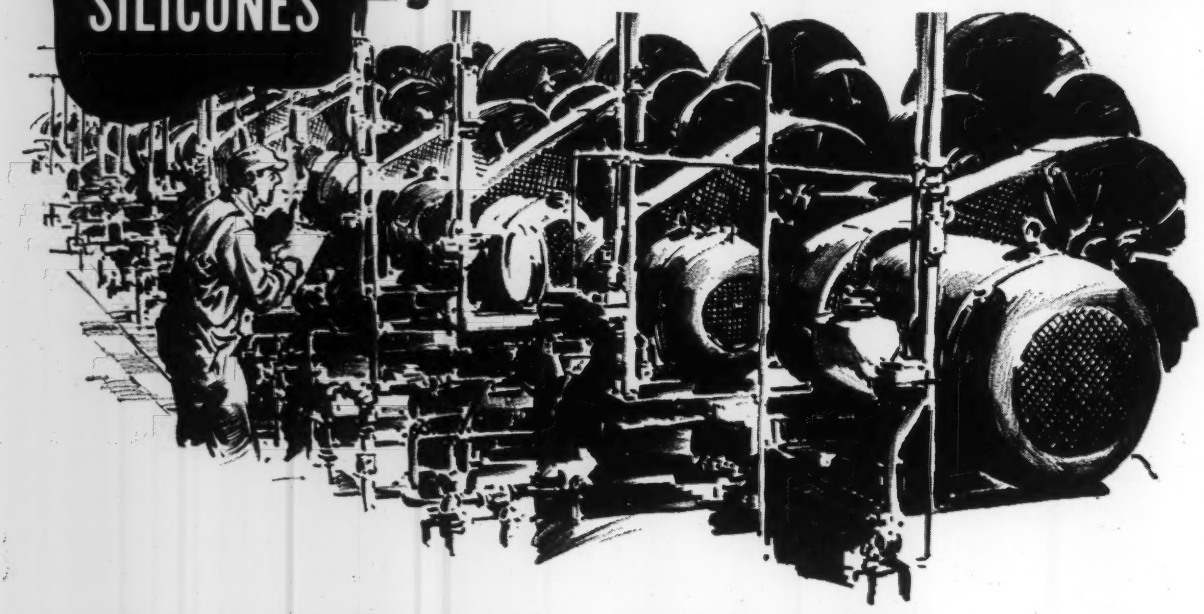
give motors more muscles



Gained 30% more pumping capacity; saved about $50,000

Engineers of a leading chemical company had to increase pumping capacity in one production unit by 30%. They did so by having 31 motors with name plate ratings of 50 and 60 hp at 850 rpm, rewound with Class H insulation to put out 75 to 90 hp at 1150 rpm.

New 75 hp motors with conventional insulation plus installation would have cost $68,200. Rewinding, plus installation on the original mounts, cost about $19,000. That's an initial saving of almost $50,000.

Equally important has been the added life and reliability of these Class H motors. The old 50 and 60 hp motors burned out at the rate of one a month or 48 failures in 4 years. Rewound with Class H insulation, these same motors have been delivering at least 50% more power for the past 4 years with only 6 failures.

That's why more and more engineers and management men specify Class H insulation for hard working motors, for critical motors that determine productive capacity, and for motors subjected to high ambient temperatures and excessive moisture or corrosive chemicals.

It has been proved over and over again that Class H insulation made with Dow Corning Silicones has 10 to 100 times the life expectancy of the next best class of insulating materials; can be used to increase the power per pound ratio in electric machines by as much as 50%.

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You can also reduce or eliminate motor outages due to bearing failure; specify Dow Corning 44 Silicone Grease for motor bearings.

In open and single shielded bearings designed for high temperature operation, Dow Corning 44 has 8 to 10 times the life expectancy of conventional greases. It gives life-time lubrication in permanently sealed bearings.

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possible the use of correct speeds for threading without limiting the selection of higher speeds for forming, drilling and similar operations. Features full antifriction-bearing spindle; production rates ranging from 12 seconds to 13 minutes per piece; compact driving mechanism completely enclosed and automatically lubricated; vertical slide which provides auxiliary tool mounting. *Brown & Sharpe Mfg. Co., Providence, R. I.*

Oxyacetylene Torch Guide: Automatically controls speed and path of torch travel. Strong permanent magnetic field provides positive attraction of power driven friction rotor to edge of a steel pattern. Speed control provided for cutting material from 1/16 to 8-in. thick. Accurate within 1/64-in. Variety of complex patterns may be used, including a 63-in. straight line, 32-in. diameter complete circle and 76-in. diameter semicircle. Table, standard and stub floor models available. *Heath Engineering Co., Fort Collins, Colo.*

Hydraulic Surface Grinder: Model OSB built by Churchill Machine Tool Co. Ltd. of England; has completely centralized controls. Cross-feed graduations are in 0.0001-in. divisions; vertical adjustment of wheel head is also calibrated in 0.0001-in. divisions. Designed for maximum rigidity and maintenance of alignment. Has variable hydraulic table traverse up to 60 fpm; cross feed up to 0.150-in. at each stroke. Grinding wheel is driven by a 2-hp motor. Table ways have independent pump feed lubrication and are protected by heavy steel guards. *British Industries Corp., International Machinery Div., New York, N. Y.*

Gear Shapers: Redesigned series 1800 machines have capacities ranging from 1 to 10-in. diameter gears with maximum face widths ranging from 2¾ to 4½ in. For cutting of spur gears; involute, angular, straight-sided and inverted splines; sliding clutches; toothed parts; ratchets and special forms. Model 18105 has 5-in. cutter head stroke. Design improvements include: standard adjustment ring with two indicators for controlling

where
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INTERVAL TIMERS
TIME DELAY RELAYS
PERCENTAGE TIMERS
RUNNING TIME METERS
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SYNCHRONOUS MOTORS ALSO CLUTCH, REVERSIBLE AND CHART DRIVE TYPES
Cramer
As specialists in TIME as a factor of CONTROL, we have developed a wide range of timing devices, extensively used on electrically-operated commercial and industrial equipment where accurate, dependable timing is essential to insure efficient product performance . . . to add convenience of operation . . . to prevent work spoilage and protect equipment itself.
Although the majority of timing problems can be effectively solved by devices considered "standard" in our line, we have had a great deal of experience in the design of special devices to meet specific requirements . . . and will welcome the opportunity to help solve your timing problem. Write us for complete information.
THE R. W. CRAMER CO., INC.
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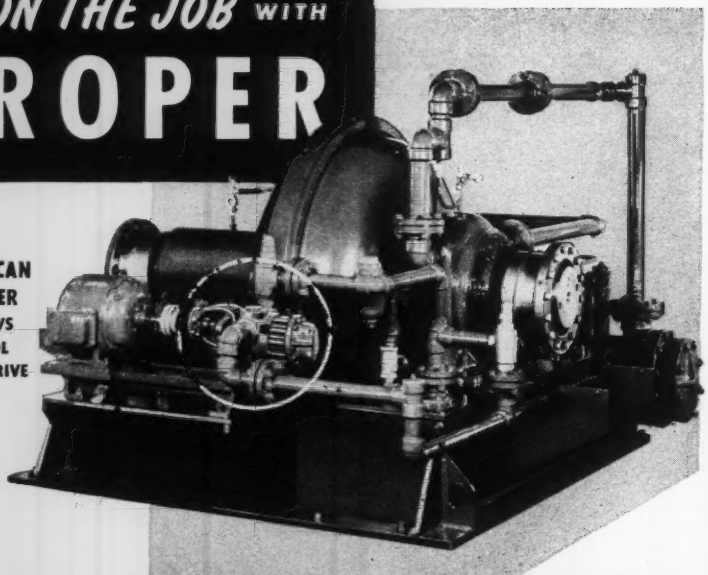
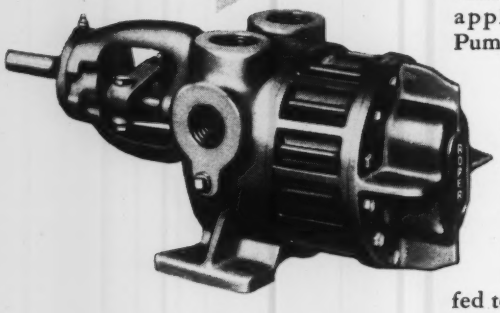
ON THE JOB WITH
ROPER



ANOTHER EXAMPLE SHOWING ROPER PUMPS AS INTEGRAL PARTS OF MODERN MECHANISMS



Gyrol Fluid Drives — for supply pumps, compressors, draft fans, and other industrial applications — use Roper Pumps to govern speed variation. In this model, the oil is taken from the oil reservoir and is added to the Fluid Drive working circuit to increase speed, or oil is removed from the circuit to decrease speed. The lubricating oil is constantly fed to all bearings. The Fluid Drive unit shown is a size 27 Type VS with maximum ratings of 518 HP at 1400 RPM.

SERIES F PUMP

Roper Series F Pumps — the models used as original equipment on Gyrol Fluid Drives — are recommended for pressures up to 300 PSI and come in 1 — 300 GPM sizes. They feature 4-port design offering eight optional piping arrangements (4 for CW and 4 for CCW rotations) . . . a factor which cuts installation time and costs. Equal size gears run in axial hydraulic balance; pumps furnished in standard or stainless steel fitted models; available with or without relief valve — with mechanical seal or packed box. Investigate what Roper Rotary Pumps can do for you!

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ROPER
Rotary Pumps

tooth spacing; air-cylinder operated clamping flange and pilot diameter to insure positive work alignment; coolant and lubricating pumps mounted outside machine base. Handwheels replace ratchet mechanism to reduce time required to remove and replace cutter head. Automatic compensating taper wedges lock head in cutting position. Two rest plates, one at each side of cutter head, prevent head deflection. *Michigan Tool Co., Detroit, Mich.*

Hand Grinders: Three models for use with mounted wheels and abrasive points. Model 137 is equipped with 5/32-in. capacity geared chuck and has a speed of 20,000 rpm; Model 146 also has a speed of 20,000 rpm, but is equipped with ⅛ and ¼-in. collet chucks; and Model 148 has speed of 36,000 rpm with ⅛ and ¼-in. collet chucks. Models 137 and 146 have capacity of 1¾ in. and smaller shank accessories; Model 148 has capacity of 1 in. and smaller. Supplied with steel carrying case with rack for mounted wheels and points. *Skilsaw Inc., Chicago, Ill.*

Solderless Wire Terminator: Capable of applying terminals at rates up to 4000 per hour. For accurate mass production of precision wire terminations; especially suited for the aircraft, automotive, electronics, railroad and appliance industries. Solderless terminals in strips are fed from a reel into the machine which operates either automatically, when the wire is placed in the target area, or by Micro Switch foot pedal. Preset precision crimping dies cut terminal from the strip and crimp it to the wire. May be bolted to work bench and plugged into a 110-v ac outlet. Size: 35 in. high, 24 in. wide, 30 in. deep; weight, 225 lb. *Aircraft-Marine Products Inc., Harrisburg, Pa.*

Drill Press Feed: "Sensitorque" for deep hole drilling. Measures drill torque; drill is withdrawn from hole only when strain approaches danger point. Eliminates needless withdrawals. Consists of sensor cabinet mounted on standard Bellows Model DFE 2-540 drill press feed. Utilizes aircraft type

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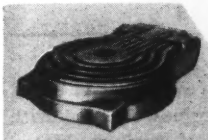
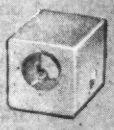
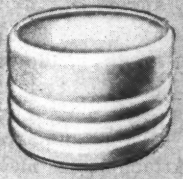

Base For Power Lawn Mower

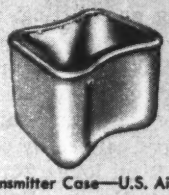
Commercial Fruit Juicer

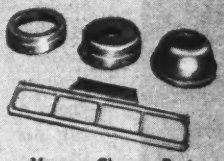

Solenoid Cover U.S. Navy


Washing Machine Tub

Fuel Tank

Gas and Water Cans U.S. Quartermaster


Transmitter Case—U.S. Air Force


Vacuum Cleaner Parts

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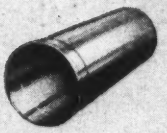
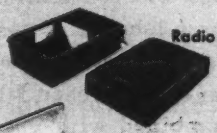
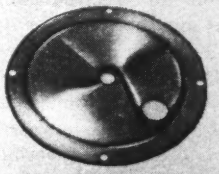
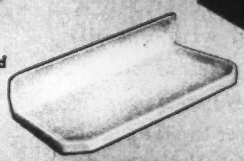

Longhorn Cheese Mold


Radio Case—U.S. Signal Corps


Cover for Ice Cream Freezing Equipment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Safety Guard for Power Tools

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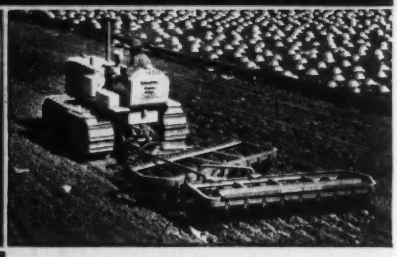
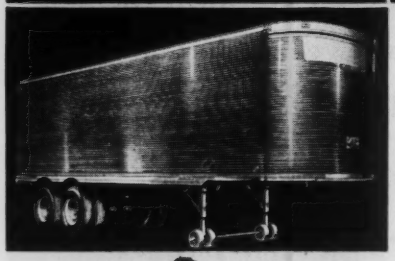
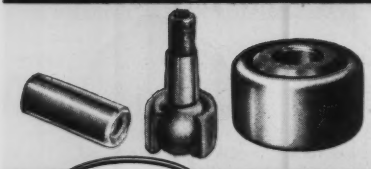




Since 1913 O & S has manufactured self-lubricated bearings and bushings. The components of these lubricant impregnated bearings are an especially woven fabric combined with a minimum of critical metal.
Are these self-lubricating bearings the answer to *your* problem? Write today for Bulletin 151.



NeverOil
SINCE 1913
O&S BEARING CO.
303 SOUTH LIVERNOIS • DETROIT 17, MICHIGAN

New Machines

relays. If drill (even one as small as 0.094-in.) becomes clogged with chips, runs dry of coolant, hits a blow hole or seizes in any way, an electrical impulse to the drill feed withdraws the drill and immediately returns it to working position. Amount of withdrawal is adjustable, all the way out of the hole, or as short a way as desired. Drill point does not hit the bottom of the hole on its return, but is eased into work. By means of a rheostat, unit can be set to react to drill torque ranging from a few inch-ounces up to full spindle motor power. Provides one and one-half turns of the drill-feed pinion, or approximately 6 in. maximum drilling stroke. Develops thrust ranging between 5 and 7½ times applied air pressure, depending upon ratio of the feed gearing. *The Bellows Co., Akron, O.*

High-Speed Disk Grinder: Small, precision Diskette designed for one-hand operation. Polishes, grinds, sharpens and shapes all types of metals to a high degree of accuracy. Attachments make possible hole burring, hole polishing, rotary filing and cutting, and solder cutting. Operates at speed of 8000 rpm. Has 110-v ac or dc motor air-cooled by a fan in the housing. Filter protects motor from dust and grit carried by cooling air. Size: 9 in. long; 2¾ in. diameter; weight, 4½ lb. *Balmar Corp., Baltimore, Md.*

Plant Equipment

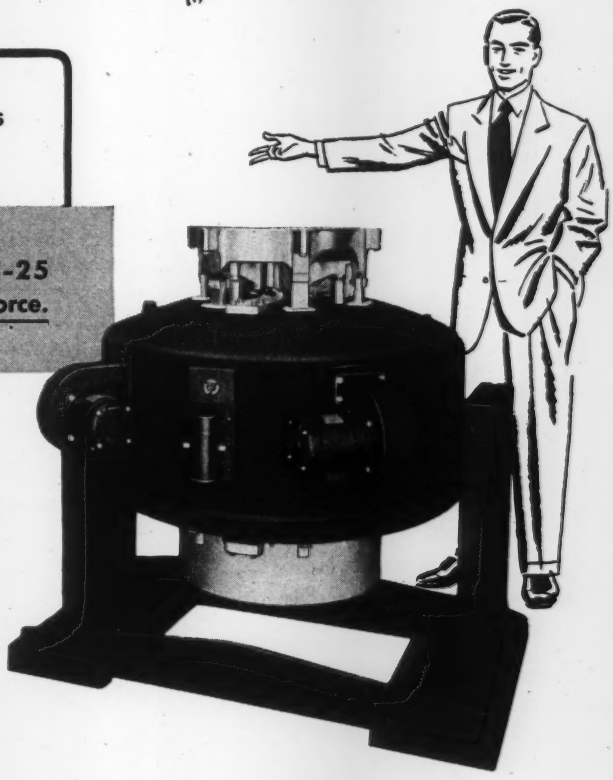
After Cooler: For compressed air or gases. Cooling accomplished by evaporation of recirculating water sprays on the surface of tubes through which compressed air passes. Designed for outdoor installation. Cooling medium is air at atmospheric wet bulb temperature, which is cooler than average summer temperature of surface cooling water. *Niagara Blower Co., New York, N. Y.*

Electric Generators: Available with or without engine. Belt drive facilitates mounting and dismounting engine. To remove, engine is

Vibration Engineering that solves your problems

PROBLEM: To perform vibration tests to MIL-E-5272 specification.

SOLUTION: The MB Model C-25 Vibration Exciter rated at 2500 lbs. force.

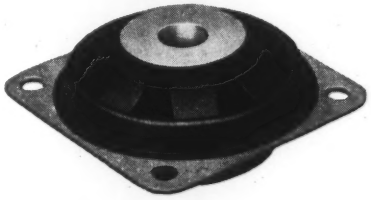


Shake testing gives a quick method of developing a product to withstand vibration. Such testing is vital for military equipment—and a good idea for any product. To meet this need, MB has applied its specialized vibration engineering to develop a range of shakers in various ratings for testing everything from electron tubes to airframes.

The big C-25 model illustrated develops large "brute forces" to satisfy specification MIL-E-5272. It has heavy duty capacity for a wide range of work, including fatigue testing. It features accurate, continuous control of force and frequency. Its control panel is available with an automatic cycling system for specific cycling tests called for in the MIL-E-5272 specification.

One of the largest and most dependable electromagnetic shakers available, the C-25 model is a good example of the quality of vibration engineering that has made MB "headquarters" for products to isolate, control, reproduce, detect, or measure vibration. More information on MB Vibration Exciters in Bulletin 1-VE-3. Write us.

Want a standard mount for vibration isolation in the special class?



With the Isomode* Type 17 Isolator, you not only conform to MIL-I-5432 specification but also get an unusual degree of isolation efficiency. It has equal spring rates in every direction. This means better control of all modes of motion. For details on this mount, write to Dept. 3.

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THE MB MANUFACTURING COMPANY, INC.
1060 STATE STREET, NEW HAVEN 11, CONN.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION • TO MEASURE IT • TO REPRODUCE IT

unbolted from its mounting base, V-belt is dropped off, and the engine is then available for other uses. Engine may be quickly reassembled with the generator. Available in capacities of 300, 500, 1350, 2500 and 10,000 watts. Mounting base is drilled to receive several popular makes of engines. *Wincharger Corp., Sioux City, Iowa.*

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Bench Type Furnace: Model VK-7 has chamber dimensions 10 by 6 by 18 in. Heating elements of 6.5 kw capacity, for 220 v single phase current are located on all four sides of the chamber and in the door, providing even heat distribution and close temperature control. Embedded design of elements protects wire against atmospheric attacks and mechanical breakage. Elements can be renewed without dismantling the furnace. *Cooley Electric Manufacturing Corp., Indianapolis, Ind.*

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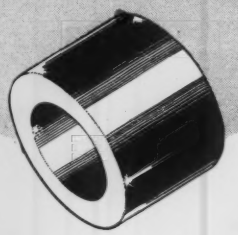
SELF-LUBRICATING
BUSHINGS



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OTHER GRAPHALLOY PRODUCTS

BRUSHES

CONTACTS

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1045 NEPPERHAN AVENUE • YONKERS, N. Y.

I've been making DURAMETALLIC Packings for over 20 Years!

DAN SMITH
23 years' experience in producing Durametallic Packings.

It pays to specify packing that has been produced by *packing specialists.* A score of men, like Dan, have been with the Durametallic Corporation for periods of 10 - 20 and 25 years. Convincing evidence why Durametallic Flexible Metallic Packings are performing the most dependable sealing jobs in industry.

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

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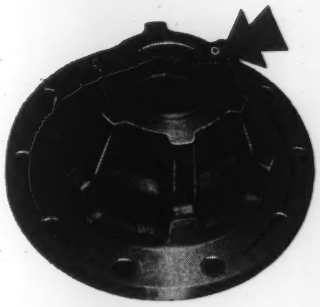

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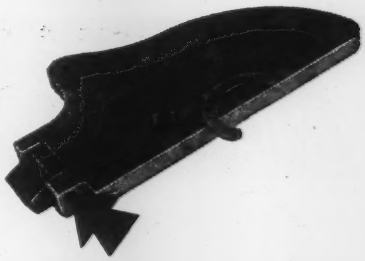

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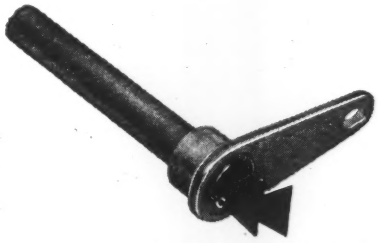

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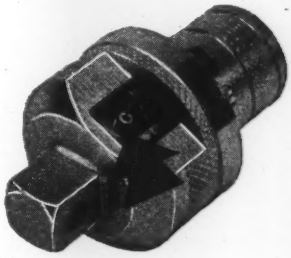

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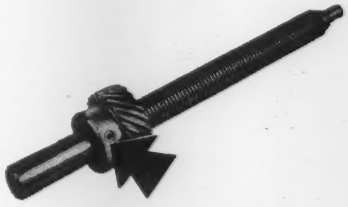

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Elastic Stop Nuts with the famous red collar are another ESNA product

ESNA TRADE MARK

MAIL COUPON TODAY. If your present operations or plans include the above applications—or set screws, rivets, hinge pins, cotter pins, pivot pins, taper pins—you can't afford to be without complete details on Rollpin. Write now—find out how much faster and cheaper Rollpin can do the job.

Section RI-84, Elastic Stop Nut Corporation of America
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Please send me the following free information on ESNA self-locking fasteners:

☐ Rollpin bulletin and sample Rollpins ☐ AN-ESNA conversion chart
☐ Elastic Stop Nut Bulletin ☐ Here is a drawing of our product. What fastener do you recommend?

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Firm_____

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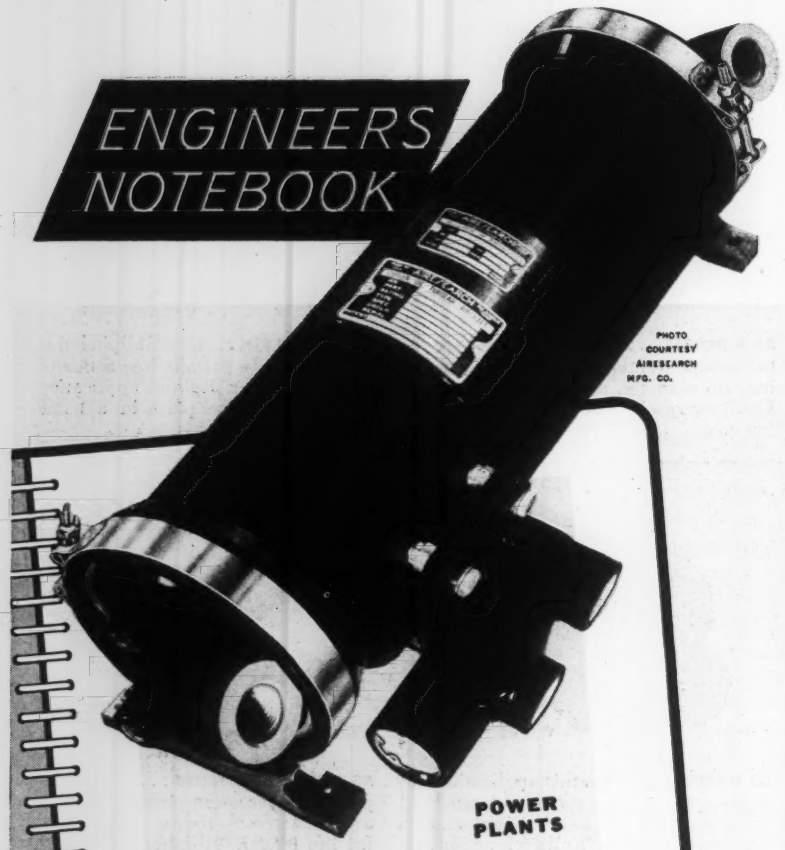

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POWER PLANTS

Quick Acting Support for Removable Core Oil Cooler

A standard Marman Support Clamp is used to attach the new AiResearch Removable Core Oil Cooler to a turbine engine. The patented T-Bolt Latch allows cooler to be mounted or dismounted speedily while providing maximum security under stress and vibration. The clamp is a standard Marman part, easy to specify and produce, and familiar to all production personnel. A simple cradle has been added for attachment to the structure. It allows trouble-free mounting at all angles and results in a lightweight, compact assembly.

These support clamps are being used today on virtually all aircraft in production for attaching a wide variety of components.

FOR INFORMATION WRITE DEPT. M-8

MARMAN PRODUCTS CO., Inc.
11214 EXPOSITION BLVD.
WEST LOS ANGELES 64, CALIF.

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STANDARD CLAMPS FOR SPECIAL APPLICATIONS

cycle begins, the cold chain and lugs move into position in contact with the work trays. Mounts on floor. Overall dimensions: width, 5 ft, 11 in.; length (less loaders), 12 ft; length (with loaders), 26 ft, 8 in. Hearth dimensions: width, 30 in.; depth, 48 in.; height, 20 in. *Ipsen Industries Inc., Rockford, Ill.*

Testing and Inspection

Chilling Machine: Model R-70, recommended for testing procedures with temperature requirements of −10 to −80 F. Equipped with a chilling chamber 30 by 18 by 33 in. deep, with more than 22 sq ft of freezing surface. Has a thermal capacity of 800 Btu's per hour at −70 F. Outside dimensions: height, 47 in.; length, 48 in., width, 43 in. *Sub-Zero Products, Cincinnati, O.*

Pressure Tester: Indicates pressure of ram on work in presses. Can be used either vertically or horizontally. Self-contained hydraulic unit, accurately calibrated. Made in sizes of 0 to 10,000 lb pressure; 0 to 50,000 lb, and 0 to 100,000 lb. Pressures over 100,000 lb available. *Studebaker Machine Co., Maywood, Ill.*

Electronic Surface Comparator: Portable instrument to determine surface roughness at the point of production. Has roughness range of 1 to 100 microinches rms. Evaluates the quality of a surface finish and indicates the index in microinches rms on a meter with the needle at an arrested position. Design of probe permits its use on radial, longitudinal, internal and external curved surfaces. Has steel cabinet with carrying handle. Size: 8¾ by 10⅞ by 10 1/16 in. Weight, 17¾ lb. *Kota-Meters Inc., Dallas, Tex.*

Gear Rolling Fixture: Has column type work head. Indicates errors in both size and concentricity of work gear; also reveals excessive tooth roughness. Adjustable work head is set at precise center distance from the master gear spindle carried on a floating spring-loaded slide. When work

How to make friends

of your customers' plant engineers....

good judgment calls for

PARKER-KALON®

when good design calls for

SOCKET SCREWS

The opinion of your customers' plant engineers and maintenance crews carries a lot of weight when the time comes to order additional equipment.

You can make friends for your product by assembling it with P-K Size-marked Socket Head Cap Screws. Each screw has the size clearly incised on the head. It's easy to tell which screw goes where.

Saves you time in product assembly, too. Sizes are issued correctly, used correctly. There's no time lost checking and changing, no spoiled work. It puts screws back in use that might otherwise be wasted because sorting is "too much bother".

Since there are no better quality Socket Screws available at any price, why not give your product the plus of the exclusive P-K Size-marked Gear Grip features? Ask for samples. Parker-Kalon Corporation, 200 Varick Street, New York 14.

DELIVERIES ARE BETTER CHECK WITH P-K FIRST

Your P-K DISTRIBUTOR *has good news. His stocks of P-K Screws are steadily improving. The size and type you need may now be readily available. Ask him about it. Remember— "If it's P-K . . . it's O.K."*

SIZE-MARKED SOCKET HEAD CAP SCREWS • GROUND THREAD SOCKET SET SCREWS • FLAT HEAD SOCKET CAP SCREWS • STRIPPER BOLTS • PIPE PLUGS • HEX KEYS

• Self locating. Shank protects threads from weld splatter. No retapping.
• Round shape. No indexing in assembly. Compactness permits use on narrow flanges.
• Engineered projections. No burn-outs in thin sheets. Simple electrodes. No pilots required.

THE
FIRST
GREAT IMPROVEMENT IN
WELD FASTENERS

PEM Self-Locating Weld Fasteners are "common-sense engineered," based on the experience of hundreds of users of weld fasteners.

They will speed your assembly, cut equipment and labor costs and do a better fastening job, wherever load carrying threads are required in thin metals that may be welded.

Write for literature and samples for trial. Penn Engineering & Manufacturing Corp., Doylestown, Pa.

PEM

New Machines

gear is rolled in mesh with the master gear, errors are indicated directly on a dial indicator actuated by movement of the master gear slide. Column type work head assures maximum rigidity. Counterbalanced gear center facilitates quick setup. Spring-loaded work center eases loading and unloading. *National Broach & Machine Co., Detroit, Mich.*

Sine Plates: For precision checking of angles on large workpieces. Available in 5 and 10-in. sizes. Top area of 5-in. plate is 6 by 6 in.; top area of 10-in. plate, 7 by 12 in. For checking compound angles, 5-in. plate can be used in conjunction with another of that size or with a 10-in. plate. Also, either plate can be used with a 5-in. sine bar. Features "three-point" base arrangement — two short cylinders spaced 5¼-in. apart between centers are used in place of the single piece base cylinder commonly employed in sine fixtures. Lapped and serrated working surfaces are held flat and square within close tolerances—5 in. plate, within 50 millionths; 10-in. plate, within 75 millionths. Tapped holes in side and end of plates accommodate clamping fixtures. Holes are provided through working plate for locating dowels or for hold-down screws. Side rails on each plate prevent test pieces from sliding off. *The DoAll Co., Des Plaines, Ill.*

Woodworking

Dustless Sander: Model 503 for rough sanding or finishing. Can be used on wood, metal, plastic and glass. Recommended for prepainting preparation, resurfacing desks and furniture, fitting doors, drawers and millwork. Over 85 per cent of sanding dust is picked up by vacuum system. This dust pick-up system thus prevents the belt from clogging. Has worm gear jackshaft with heaviest shaft section at the center where strains are greatest. Belt speed is 1120 sfpm. Trigger switch is equipped with lock button. Size: 16¾ in. long, 8 in. high, 5½ in. wide. *Porter-Cable Machine Co., Syracuse, N. Y.*

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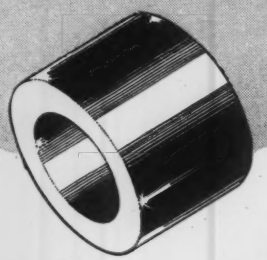

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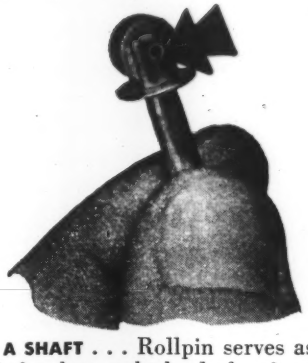

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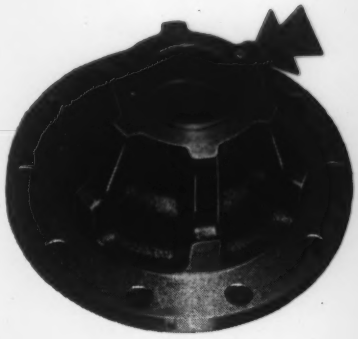

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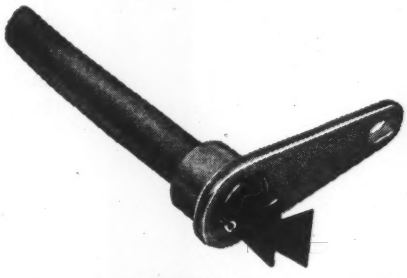

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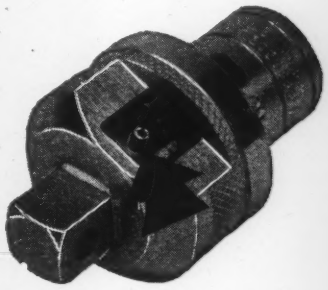

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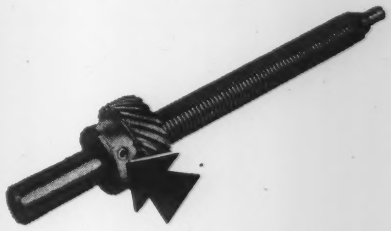

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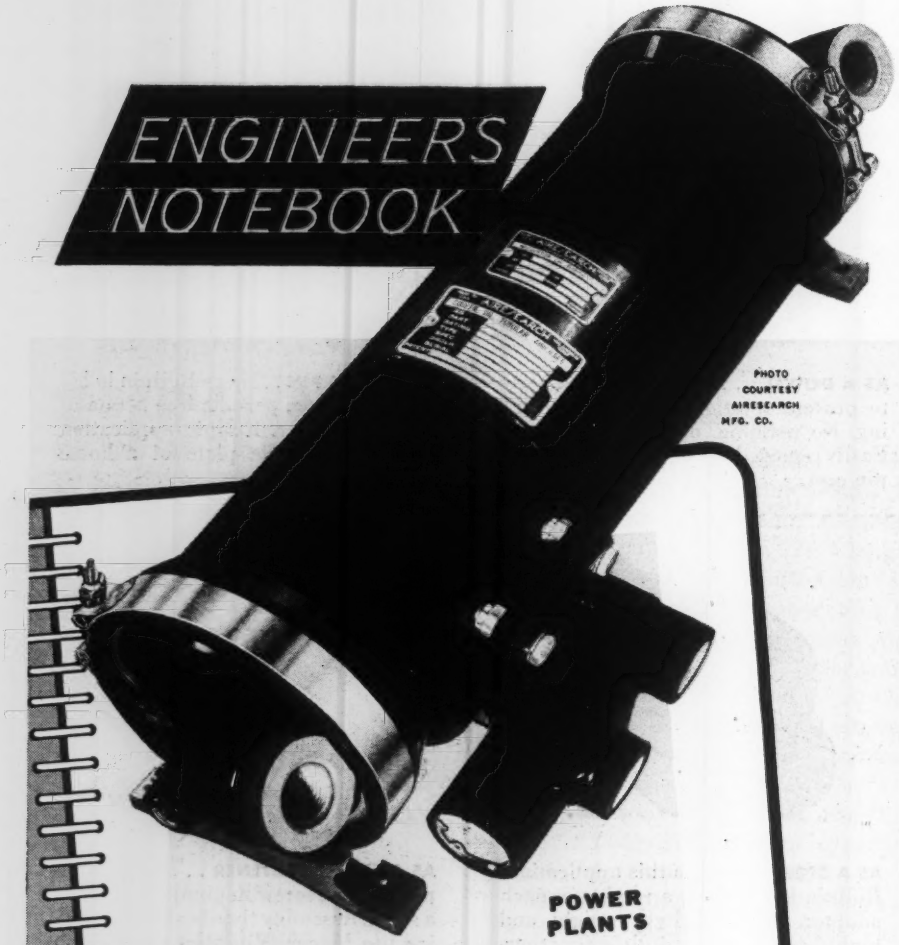

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POWER PLANTS

Quick Acting Support for Removable Core Oil Cooler

A standard Marman Support Clamp is used to attach the new AiResearch Removable Core Oil Cooler to a turbine engine. The patented T-Bolt Latch allows cooler to be mounted or dismounted speedily while providing maximum security under stress and vibration. The clamp is a standard Marman part, easy to specify and produce, and familiar to all production personnel. A simple cradle has been added for attachment to the structure. It allows trouble-free mounting at all angles and results in a lightweight, compact assembly.

These support clamps are being used today on virtually all aircraft in production for attaching a wide variety of components.

FOR INFORMATION WRITE DEPT. M-8

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MARMAN PRODUCTS CO., Inc.
11214 EXPOSITION BLVD.
WEST LOS ANGELES 64, CALIF.

SAVE COST, TIME AND WEIGHT WITH MARMAN

STANDARD CLAMPS FOR SPECIAL APPLICATIONS

cycle begins, the cold chain and lugs move into position in contact with the work trays. Mounts on floor. Overall dimensions: width, 5 ft, 11 in.; length (less loaders), 12 ft; length (with loaders), 26 ft, 8 in. Hearth dimensions: width, 30 in.; depth, 48 in.; height, 20 in. *Ipsen Industries Inc., Rockford, Ill.*

Testing and Inspection

Chilling Machine: Model R-70, recommended for testing procedures with temperature requirements of −10 to −80 F. Equipped with a chilling chamber 30 by 18 by 33 in. deep, with more than 22 sq ft of freezing surface. Has a thermal capacity of 800 Btu's per hour at −70 F. Outside dimensions: height, 47 in.; length, 48 in., width, 43 in. *Sub-Zero Products, Cincinnati, O.*

Pressure Tester: Indicates pressure of ram on work in presses. Can be used either vertically or horizontally. Self-contained hydraulic unit, accurately calibrated. Made in sizes of 0 to 10,000 lb pressure; 0 to 50,000 lb, and 0 to 100,000 lb. Pressures over 100,000 lb available. *Studebaker Machine Co., Maywood, Ill.*

Electronic Surface Comparator: Portable instrument to determine surface roughness at the point of production. Has roughness range of 1 to 100 microinches rms. Evaluates the quality of a surface finish and indicates the index in microinches rms on a meter with the needle at an arrested position. Design of probe permits its use on radial, longitudinal, internal and external curved surfaces. Has steel cabinet with carrying handle. Size: 8¾ by 10⅞ by 10 1/16 in. Weight, 17¾ lb. *Kota-Meters Inc., Dallas, Tex.*

Gear Rolling Fixture: Has column type work head. Indicates errors in both size and concentricity of work gear; also reveals excessive tooth roughness. Adjustable work head is set at precise center distance from the master gear spindle carried on a floating spring-loaded slide. When work

How to make friends

of your customers'

plant engineers . . . .

good judgment calls for

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SOCKET SCREWS

The opinion of your customers' plant engineers and maintenance crews carries a lot of weight when the time comes to order additional equipment.

You can make friends for your product by assembling it with P-K Size-marked Socket Head Cap Screws. Each screw has the size clearly incised on the head. It's easy to tell which screw goes where.

Saves you time in product assembly, too. Sizes are issued correctly, used correctly. There's no time lost checking and changing, no spoiled work. It puts screws back in use that might otherwise be wasted because sorting is "too much bother".

Since there are no better quality Socket Screws available at any price, why not give your product the plus of the exclusive P-K Size-marked Gear Grip features? Ask for samples. Parker-Kalon Corporation, 200 Varick Street, New York 14.

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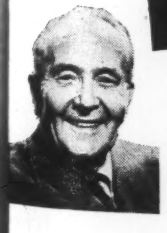

Your P-K DISTRIBUTOR *has good news. His stocks of P-K Screws are steadily improving. The size and type you need may now be readily available. Ask him about it. Remember— "If it's P-K . . . it's O.K."*

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